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COMPARING BENEFIT ESTIMATION TECHNIQUES: RESIDENTIAL FLOOD HAZARD REDUCTION BENEFITS IN ROANOKE, VIRGINIA

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DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, WATER RESOURCES SUPPORT CENTER
INSTITUTE FOR WATER RESOURCES
CASEY BUILDING
FORT BELVOIR, VIRGINIA 22060-5586

REPLY TO
ATTENTION OF

CEWRC-IWR

17 Jul 1998

MEMORANDUM FOR COMMANDER, Defense Technical Information Center, Cameron Station, Alexandria, VA 22314

SUBJECT: Transmittal of

1. Reference AR 70-31.

2. Two copies of "Comparing Benefit Estimation Techniques: Residential Flood Hazard Reduction Benefits in Roanoke, Virginia," IWR Report 98-R-2, have hereby been submitted.

3. Initial distribution of this report has been made to appropriate Corps of Engineers agencies. It is recommended that copies of this report be forwarded to the National Technical Information Center.

4. Request for the DTIC Form 50 (Incl 2) be completed and returned to WRSC-IWR.

FOR THE DIRECTOR:

Kyle E. Schilling
Director

Enclosures

COMPARING BENEFIT ESTIMATION TECHNIQUES: RESIDENTIAL FLOOD HAZARD REDUCTION BENEFITS IN ROANOKE, VIRGINIA

By

Leonard Shabman, Kurt Stephenson, Eric Thunberg, and Brian Dietz

With

Paul Driscoll and Kevin O'Grady

For

U.S. Army Corps of Engineers
Institute for Water Resources
Casey Building
7701 Telegraph Road
Alexandria, VA 22315-3868

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PREFACE

This report is a product of the U.S. Army Corps of Engineers' Risk Analysis for Water Resources Investments Research Program managed by the Institute for Water Resources which is a unit of the Water Resources Support Center. The report conforms to the basic planning model and to the analysis recommendations presented in "Economic and Environmental Principles and guidelines for Water related Land Resources Implementation Studies" (P&G).

The purpose of this research project was to evaluate the differences and potential strengths and weaknesses of different methods for evaluating consumers' willingness to pay for a public good, i.e., a flood hazard reduction project. Three methods are compared and contrasted both collectively and against the theory of revealed consumer preference. These are the Property Damages Avoided (PDA) approach, Hedonic Price Method (Land Price Analysis), and the Contingent Value Method (CVM).

The report consists of nine sections, a bibliography, and two appendices. The sections provide historical and other situational background information on the location of the proposed project, an overview of the revealed preference approach and P&G guidance for evaluating willingness to pay, a detailed description of each method and its application in the study, and the resulting findings. The first appendix displays the contingent valuation survey forms and procedures used, while the second appendix presents the questions asked to subject consumers of the study concerning a bond referendum to pay for the proposed project.

This report was prepared by the authors under terms of a contract with the U.S. Army Corps of Engineers Institute for Water Resources. Leonard Shabman, Paul Driscoll, and Kurt Stephenson are, respectively, Professor, Assistant Professor, and Visiting Professor in the Department of Agricultural and Applied Economics at Virginia Polytechnic Institute and State University. Brian Dietz and Kevin O'Grady are former graduate students of the department. Eric Thunberg is an economist with Northeast Fisheries Science Center, National Marine Fisheries Service. Dr. David A. Moser was the contract manager for the report and is the manager of the Risk Analysis for Water Resources Investments Research Program. The Chief of the Technical Analysis and Research Division is Mr. Michael R. Krouse and the Director of IWR is Mr. Kyle Schilling. Mr. Robert Daniel, Chief of Economics and Social Analysis Branch, Planning Division, HQUSACE and Mr. James Crews, formerly of HQUSACE, served as technical monitors for this research. Numerous field reviewers provided valuable insights and suggestions to improve early drafts.

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INTRODUCTION AND OBJECTIVES

1.1 Introduction

The Flood Control Act (FCA) of 1936 continues to provide the primary policy framework for the federal government's role in flood control project construction. In addition to defining the federal role in general terms, the 1936 Act, along with the 1938 Flood Control Act, defined the limit of federal financial responsibility by establishing inter governmental cost sharing requirements for project construction, operation, and maintenance. These acts placed primary financial responsibility with the federal government. Despite the recent passage of PL 99-662 which partially expanded the non-federal government's financial responsibility, a substantial federal financial presence in payment for flood project construction will continue. Therefore, despite this recent legislation there will continue to be a need to set priorities among alternative flood control projects for the allocation of a limited federal construction budget.

In the setting of spending priorities for federal funds the policy mandate of the 1936 Act remains in effect:

> ...the Federal Government should improve or participate in the improvement of navigable waters or their tributaries, including watersheds thereof for flood control purposes if the benefits to whomsoever they may accrue are in excess of the estimated costs and if the lives and social security are otherwise adversely affected. (FCA, 1936)

This often quoted language of the 1936 FCA establishes a broad and imprecise framework for the assessment of residential flood hazard reduction benefits. At the most general level, it suggests not only a concern for the economic losses associated with property damage, but also a concern for the lives and social security of the people, i.e., a nonproperty focus. Nonetheless, despite this broad evaluation mandate dating back over 50 years, no professional or public policy consensus has emerged for defining the procedures that will be best suited for assessing residential flood control benefits.

1.2 Assessing Residential Flood Control Benefits

The U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies (P&G 1983) is the most recent distillation of the nearly 50 years of planning experience following the 1936 FCA. The P&G provides the fundamental guidance that water resource planners are to follow in preparing estimates of residential flood control benefits. The P&G instructs the water resource planner to define the benefit of a project in terms of the beneficiary's, in this case the flood plain occupant's, "willingness to pay" for project output. The willingness to pay rationale is the basic evaluation principle in the P&G. In Section 1.7.2 (b) the standard willingness to pay is described:

The general measurement standard of the value of goods and services is defined as

> the willingness of users to pay for each increment of output from a plan. Such a value would be obtained if the "seller" of the output were able to apply a variable unit price and charge each user an individual price to capture the full value of the output to the user (P&G).

The willingness to pay rationale treats a flood control project as a commodity, which could, in principle, be sold to flood plain occupants. Because this measurement standard is a direct analogy to the operation of a market pricing system where the perfectly discriminating monopolist can extract payments from willing buyers, this measurement rationale may be termed the market rationale for benefits assessment. Benefits are defined as the maximum revenue that the government, as a sole seller of flood control services, could extract from flood plain landowners in a hypothetical market.

Like the language in the 1936 FCA, the willingness to pay principle conceptually allows for not only the estimation of the property damages avoided, but also for avoided post-flood trauma such as medical bills or worker productivity losses, avoided pre-flood anxiety based nonproperty benefits, and avoided social and economic disruption of the community. Thus with this rationale, both property and nonproperty benefits of flood hazard reduction can be accounted for by the subjective assessment of the flood plain occupant and then reflected in their willingness to pay for the reduced flood hazard. In addition, the willingness to pay principle does not conceptually confine flood control benefits to flood zone residents since citizens living outside the flood plain may also be willing to contribute financially to the construction of a flood control project.

The P&G requires benefits to conceptually measure a project beneficiary's willingness to pay as the area under a demand curve for reduced flood risk. However, given absence of markets for services such as flood control, the P&G does recognize that direct estimation of benefits from market price data is impossible. Therefore, several alternative methods are approved to approximate residential flood control benefits. The P&G carefully defines two allowed methods for the estimation of willingness to pay for flood control: the present value of property damages avoided (PDA) and changes in land prices.[1] The most widely used method, the PDA, has been used to estimate flood hazard reduction benefits since the passage of the flood control acts in the 1930s (Shabman 1989). In fact, Section 2.4.2 (a) of the P&G states that the general benefit measurement standard for flood hazard reduction is "...the reduction in actual or potential damages associated with land use."

For a particular residential property, the property damages avoided method estimates expected dollar damages inflicted by different floods where each flood has a different probability of occurrence. Future costs in terms of property damages avoided as a result of the flood control project and the present value of avoided costs are used to estimate landowner willingness to pay for the project. Total expected damages are measured by summing the probability weighted damages where damages are calculated as the costs of replacing or repairing the property to its physical state

[1] The most recent guidelines for using the PDA and restoration of land market values method is contained in the National Economic Development Procedures Manual: Urban Flood Damage, Institute for Water Resources, Report 88-R-2, 1988.

prior to the impact of the flood. Flood damage reduction for a given year from a flood control project is estimated as the difference between total expected damages with the project and total expected damages without the project. This analysis is repeated for each year in which benefits and costs occur. This projected time frame is called the planning horizon. The total benefit estimate from the project is measured by the present value of the annual benefits in the planning horizon computed at the project discount rate.

While the willingness to pay rationale is defined as the benefit standard elsewhere in the P&G, that rationale is not mentioned in reference to the section on PDA. It appears that the P&G implicitly assumes that the willingness to pay measurement standard is adequately represented by PDA even though the reduced flood control damages considered is oriented exclusively towards physical property. This method measures total willingness to pay only when a set of rather restrictive assumptions hold. If these assumptions are violated, the PDA method will likely under represent the landowner's willingness to pay for a reduction in flood hazards.

The narrow focus of the PDA method on property damages, however, has long been recognized in federal benefit estimation guidelines (Federal Inter-Agency River Basin Committee, 1950; Water Resources Council, 1969; 1973; and 1983). In the political arena where project investment priorities were set, the simple calculations of PDA benefits were part of a broader consideration of the "nonproperty" effects that would be mitigated by the project (Shabman 1973).

The other technique that has been approved for the estimation of residential flood hazard reduction benefits is to estimate land price changes with verses without a flood risk reduction. This is technically known as the hedonic price method. Increases in land sale prices with versus without a project can be used as a money measure of benefits. Land prices are assumed to increase as a result of the land buyers and sellers subjective assessment of the property and nonproperty benefits of the project. This subjective assessment is reflected in money terms through land sale prices. The resulting price increment represents the present value of this subjective assessment benefit stream, discounted by an interest rate deemed appropriate by the land market traders. Nonproperty benefits could be reflected in the land price changes since nonproperty concerns such as post-flood or pre-flood anxiety may affect traders' willingness to pay and willingness to sell.

The use of land price increases to measure flood control benefits should take care to separate the effects of the project from the other factors which will affect land sales. Examples of other factors include proximity of the land parcel to shopping, lot size, and house size. Procedurally land price analysis is accomplished by using multiple regression techniques to separate the influence of flood protection from other factors influencing sale prices. The separation of property and nonproperty benefits of the land price increase, however, is generally not possible.

The use of land price analysis has a long history in the evaluation of flood control projects. Beginning with the Mississippi River Commission in the late 1800s, and continuing to the planning efforts of the Miami Conservancy District of Ohio in the 1920's, benefits from reduced flood risk were estimated as the expected difference in land prices with versus without a flood control project. These estimates were a starting point for negotiations between local flood control and levee districts and benefiting landowners on the tax payments that would be made to pay for project construction (Shabman 1989). After 1936, land price analysis was largely abandoned due to the belief that

market derived benefit estimates would inadequately capture the benefits of flood control. The idea being that market participants were not fully informed as to the risks of flooding, and hence, the expected value of flood protection. Only recently in the 1983 P&G has land price analysis been reemphasized as legitimate benefit estimation technique.

In addition to the two benefit estimation techniques described above, economists recently have developed a survey based benefit estimation technique that is capable of reflecting nonproperty, as well as property, concerns (Mitchell and Carson 1989). The contingent valuation method (CVM), which has been used to value environmental assets, directly asks individuals questions to determine their willingness to pay for a "commodity" of interest, in this case an increase in flood protection. A designed questionnaire which defines the project output, the method of payment, and asks a series of questions for defining the socio-economic characteristics of the respondent is administered to a sample of the project area population. In the administration of the questionnaire, either by mail, telephone, or personal interview, the project is defined so that the individual has sufficient information to form a subjective estimate of their willingness to pay for the project output. Then the survey respondent is asked a series of questions, including the hypothetical willingness to pay for project output. These questions permit the development of a willingness to pay function for the sampled population, which can then be used to characterize the willingness to pay function for the general population affected by the project.

The CVM approach is not explicitly approved in the P&G for flood control benefit analysis, but is listed as an approved benefit estimation approach for recreation. While conceptually capable of generating flood control benefit estimates, the CVM has yet to be applied for justifying a flood control project investment.

1.3 Objectives of this Report

To date there has been no research comparing the results of these different benefit estimation techniques. Although all of these methods are expected to measure willingness to pay, it is not known how the approved methods compare empirically. An opportunity to do such a comparison was present in the City of Roanoke, Virginia. The City of Roanoke has experienced ten floods of varying magnitude since the turn of the century with major floods in 1972 and 1978. However, it was the record flood of 1985 that motivated city officials to press for a Corps of Engineers' project comprised of flood walls, bridge replacements, and river channel improvements which would increase the capacity of the river to carry flood water (Roanoke Times and World News 1989, U.S. Army Corps of Engineers 1984).

The techniques of property damages avoided, hedonic price or land price analysis, and contingent valuation were used to estimate the economic benefits of flood risk reduction for the same residential area in Roanoke. In comparing the benefit estimates of each method, no claim will be made about which method generates the most "accurate" estimate of willingness to pay. Since each method is based on a different set of assumptions and limitations, benefit estimates are expected to differ. Thus, the goal is not to identify the method that produces the "best" estimates, but instead the objective is to examine how the techniques and benefit estimates differ and discuss the implications for future benefit estimation work.

For purposes of comparison, the contingent valuation and PDA can be classed as hypothetical choice techniques since benefits are derived from speculations made by survey respondents (CVM) or analysts (PDA). The hedonic price method can be termed an indirect revealed choice technique as benefit estimates are based on actual choices revealed in the land market, but no direct choices regarding the level of flood risk are observed. In April 1989, the City of Roanoke held a special single-issue bond referendum concerning whether to finance the city's share of the flood control project through debt issuance. The revealed voting behavior in the referendum provided a unique opportunity to compare the consistency of the estimates from the three benefit estimation techniques with direct revealed choice behavior. In addition, the referendum offers direct evidence concerning the extent to which nonproperty benefits extend beyond those living and working in the flood plain.

The specific objectives of this report can be summarized as follows:

1. To describe and summarize the land price change, contingent valuation, and property damages avoided techniques for valuing flood hazard reduction benefits in the Roanoke case study area by:

   A. describing the basic method and procedures associated with each technique.

   B. identifying the assumptions and potential limitations of each technique, including compatibility with the willingness to pay principle and the ability to capture both property and non-property benefits.

   C. summarizing the results from the application of each technique to the Roanoke study area, including identification of any apparent weaknesses in the estimation procedure and results.

2. To describe voting behavior patterns from the Roanoke referendum concerning the provision of the flood control project.

3. To compare the estimated results from all four studies for an identical set of residential properties.

1.4 Report Overview

The main body of this report is organized into eight sections. The first describes the general theoretical decision model upon which the three benefit estimation methods are based. This section also outlines the possible sources of flood hazard reduction benefits. The second section describes the history of flooding in the City of Roanoke, the Corps of Engineers flood control project in Roanoke, and the study area on which the three benefit estimation techniques were conducted. The next four sections respectively describe the property damages avoided, hedonic price or land price analysis, contingent valuation, and voting behavior studies that were conducted for a residential Roanoke neighborhood. In addition to describing the procedures and results of each study as

applied to Roanoke, the general assumptions and possible limitations of each method are discussed and summarized. Individual study procedures and results have also been reported in Driscoll, Dietz, and Alwang (1994), Thunberg and Shabman (1991), U.S. Army Corps of Engineers (1984), and Shabman and Stephenson (1992). The final two sections of the report identify how the estimates from each of the four studies compare for an identical set of residential properties and explores the possible reasons for any differences. Implications and recommendations for measurement of flood risk reduction benefits are also provided.

There are two ways the reader can proceed through this report. Readers interested only in the comparative results and report recommendations can review Sections 2, 3, 8 and 9. Those who want a more detailed discussion of the individual techniques and results from the four case studies should also read Sections 4 through 7.

SECTION 2
THEORETICAL AND CONCEPTUAL FRAMEWORK

2.1 Modeling Choice Behavior

The three benefit estimation techniques compared in this study, PDA, CVM, and Land Price Analysis, are ultimately grounded in the neoclassical economic model of rational choice. Given constraints of income and prices, individuals are viewed as ranking all possible choices in one dimension, utility. Individual's then choose the combination of goods and services where their utility is maximized. Behavioral assumptions are imposed on individual preference orderings in order to generate logically consistent choices.

Economists have expanded this utility maximizing framework to include elements of uncertainty and time through use of expected utility theory and time discounted utility theory, respectively. These models weigh choices in two additional dimensions beside utility: (1) the probability of the event occurring, and (2) the time preference of the individual. Once uncertainty and time have been added, individuals are viewed as maximizing their expected discounted utility.

Now consider someone living in an area subject to periodic flooding. Under conditions without flood protection, the individual's expected discounted utility can be represented by a utility function such as:

[2.1]
$$DEU_{WO} = \sum_{t=1}^{T} \frac{U(\lambda FD_{wot}, Y_t)}{(1+r)^{t-1}}$$

In equation 2.1, the individual's overall level of utility is a function of flood effects without the flood protection, FD_{WO}, and the value of all other goods, represented by the numeraire Y. For residential landowners and residents subject to flood risks, the adverse consequences stemming from a flood event extend beyond damages to personal property. As will be discussed more thoroughly below, individuals may also value the reduction in the flood hazard for other reasons than to protect personal property. The variable r represents the individual's personal rate of time preference, which is assumed to be constant over time, and T is the individual's planning horizon.

The uncertainty of the occurrence of flood event is represented by the probability density function, λ. Taken together, λ and FD represent the expected value of flood damages, both property and nonproperty, in any given year. Although often not distinguished in expected utility models, probabilities can be loosely thought of as being either objective or subjective (O'Grady 1992). Objective probabilities are based on statistical notions and can be defined as the frequency of occurrence in repeated trials. While simplifying the model, the assumption that individuals hold objective probabilities is not necessary. Subjective probabilities reflect the individual's own "degrees of belief" as a basis for making choices under uncertainty. Acknowledging the existence of subjective probabilities in decision making recognizes that individual choice in an uncertain setting is influenced by the characteristics of that situation and the lack of information or understanding of objective probabilities.

A flood control project increases the overall level of utility by reducing the probability of flood, or equivalently, by increasing the probability that a flood will not occur. If the construction of a flood control project reduces the probability of a flood from λ to γ, then the individual's new discounted expected utility with flood protection can be expressed as:

[2.2] $$DEU_W = \sum_{t=1}^{T} \frac{U(\gamma\, FD_{wt}, Y_t)}{(1+r)^{t-1}}$$

The difference between the DEU_W and DEU_{WO} is the gain in discounted expected utility due to a reduction in the exposure to the flood hazard resulting from the construction of the flood control project. It is the personal satisfaction associated with a reduction in the probability of flooding.

In quantifying this utility change, economists maintain the appropriate measure of welfare change is the maximum amount of income, or the value of other goods, that an individual is willing to give up in order to acquire an increase in a given good while maintaining the original level of utility. For the increase in flood protection, the monetary value of this change in utility is the reduction in income necessary in the 'with project' state to equate discounted expected utility with and without the project, $DEU_W = DEU_{WO}$. This decrease in income is thought of as the individual's willingness to pay for a flood control project. The individual's willingness to pay is the monetary value of the reduction in exposure to the adverse consequences of flooding, and can be interpreted as the individual's subjective present value of expected flow of benefits stemming from the project.

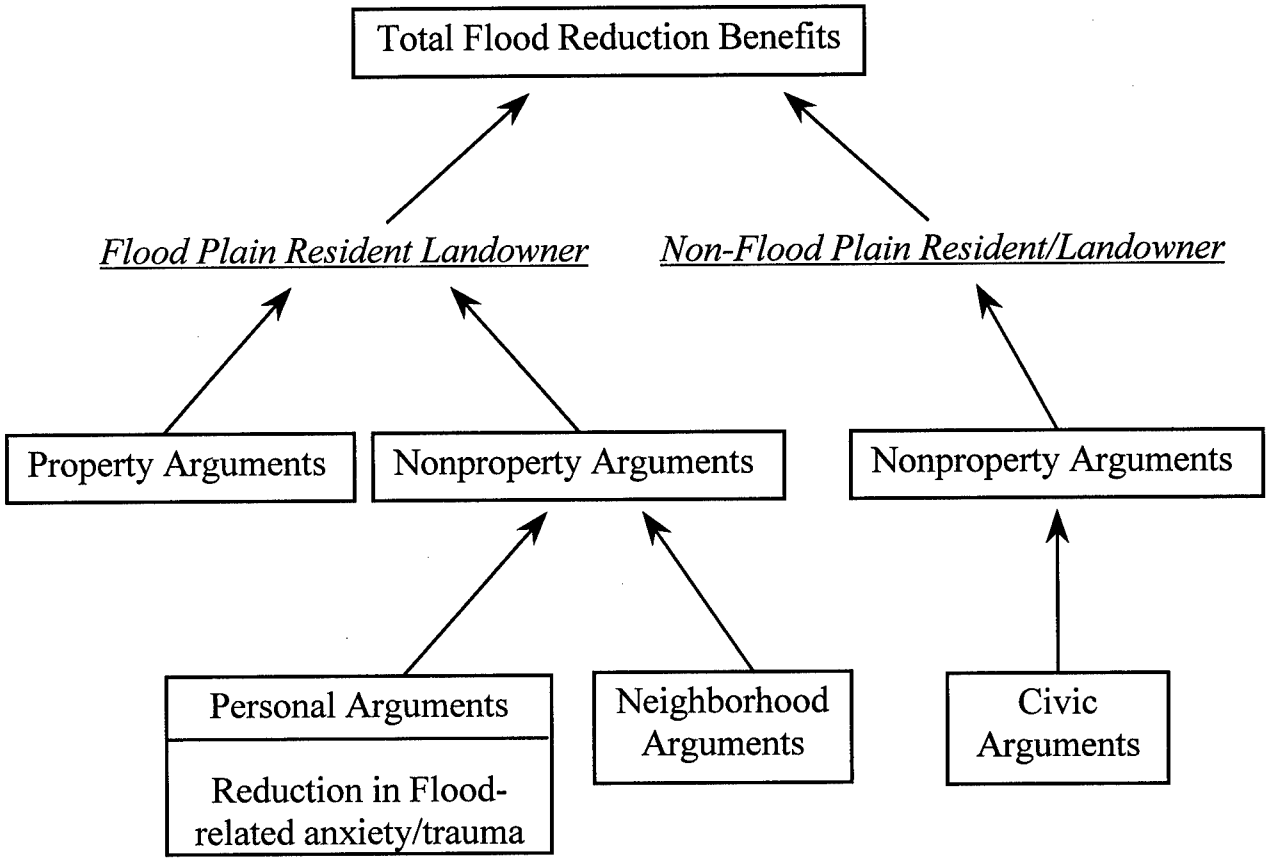
The formulation of the utility functions in equations 2.1 and 2.2 make no explicit assumptions about the risk attitudes that an individual may hold. Individuals can be thought of either as risk averse, risk neutral, or risk seeking. The risk averse individual prefers a certain outcome to an uncertain outcome even though for outcomes with the same expected value. Thus, in addition to the reduction in the expected value of flood damages, the risk averse individual would experience a utility gain simply by knowing the likelihood of a flood has been reduced. A risk neutral individual is indifferent between outcomes with different risk as long as the expected values of each choice are equal. Holding all other factors constant, the risk averse individual would be willing to pay at least as much as the risk neutral individual for flood control plus an amount equal to the monetary value of the gain in utility above expected value of reduced damages. In the case of flood control, risk seeking is not considered plausible because it could result in the perverse and unlikely conclusion that an individual would be willing to pay for a flood control project not to be built. Therefore, all individuals are assumed in this report to be either risk averse or risk neutral.

2.2 Property and Nonproperty Components in the Total Value of Flood Risk Reduction

Individuals expect to gain utility through a reduction in adverse effects from flooding, *FD* in equations 2.1 and 2.2. The arguments in an individual's utility function that are associated with a reduction in flood hazards can be thought of as falling within two broad categories - property and nonproperty components. Figure 2.1 shows four possible property and nonproperty arguments that may enter into people's subjective assessment of a reduction in flood risk. For people living or owning property in the flood plain, a flood control project reduces the expected value of property

damages. A prospective flood event can reduce the service flow of the asset either temporarily or permanently, and protection of physical assets such as land or capital provides a flow of income or utility to the asset owner. If one assumes that the employment of assets will be the same both before and after the flood event then property effects of flood protection reduce future expenditures for restoration and repair expenditures of physical assets damaged by a flood event.

Figure 2.1: Conceptual Model of Flood Risk Reduction Benefits



Yet people may value the reduction in the flood hazard for a number of reasons besides the protection of property. The 1936 Flood Control Act explicitly recognizes the nonproperty benefits of flood control as "lives and social security of the people otherwise adversely affected" by flooding. It is argued here that people living and working both in and outside the flood plain may experience a gain in personal welfare beyond personal property arguments from a reduction in flood risk.

First, people residing in the flood plain may experience negative, flood-related psychological injury caused by the threat of flooding or by an actual flood event. The adverse

psychological consequences of the flood experience has two sources:

1. Post-flood Trauma: a disordered psychic or behavioral state resulting from the emotional stress or physical injury from an experienced flood event.

2. Pre-flood Anxiety: a disordered psychic or behavioral state resulting from a sense of apprehension and fear over the prospects of flooding and self doubt about the capacity to cope with the flood threat.

Flood-induced trauma and anxiety is a personal nonproperty argument in a flood plain resident's utility function (see Figure 2.1).

Besides the reduction in personal flood-related trauma and anxiety, residents of a flood plain may also consider the neighborhood effects an important consequence of a reduction in flood risk. Flooding of a residential neighborhood can result in a general disruption of the social, economic, and public service activities of the neighborhood. Residents may not just be concerned with their personal property and well being but may also express concerns for the property and well being of their neighbors (Blocker and Rochford 1986).

Reduced property damages, anxiety, trauma, and neighborhood disruption can be conceptualized as arising primarily from flood plain residents and landowners. Nonproperty values, however, may also exist for those living outside in the form of civic pride, community obligation, or moral responsibility to help those who suffer from flooding. These nonproperty services stemming from the construction of a flood control project can be termed "civic" arguments. Civic arguments are not directly attached to the experience of flooding but instead arise from feelings of citizen's sense of community obligation or duty. People expressing civic values may also feel that flood protection enhance the potential economic development of the community. People may also feel a moral responsibility or duty to help others who suffer from random "acts of nature."

2.3 Measuring the Benefits of Flood Risk Reduction

The property damages avoided (PDA), contingent valuation method (CVM) and hedonic price (Land Price Analysis) method each aim to quantify the total welfare change associated with a reduction in flood hazards into a estimate of the individual's total willingness to pay. Yet each method makes use of a different set of behavioral assumptions and each generates estimates based on different types of technical limitations.

The techniques differ in four primary ways. First, all three methods have different capacities to reflect property and nonproperty benefits associated with a reduction in flood hazard. Second, each method imposes different assumptions about risk attitudes and personal discount rates. Third, treatment of how individuals assess the probabilities involved with flood risk vary across the three models. While the PDA, CVM, and hedonic price technique all are based on the economic model of choice outlined above, these three differences revolve around the structure and assumptions about important elements of the choice problem. The fourth primary difference between methods deals with the different processes utilized to generate benefit estimates. Each method uses different

data and measurement instruments needed to generate flood risk reduction benefit estimates.

These differences will be discussed and assessed for PDA, hedonic price, and CVM techniques in Sections 4 through 6. The potential ways these differences can influence final estimates of willingness to pay are discussed with specific reference to the Roanoke case study.

SECTION 3
THE ROANOKE CASE STUDY

3.1 Roanoke's Flood History and Channelization Project

The City of Roanoke, Virginia is located in a large valley that is situated between the Blue Ridge and Appalachian mountains. There are several small streams and one major river, the Roanoke River, flowing through the valley in which the city is located. Due to the relatively large watershed and narrow course of the Roanoke River, low-lying areas within the city have been subjected to frequent flooding. Roanoke has experienced ten floods of varying magnitude since the turn of the century, with major floods occurring in 1959, 1972, 1978 and 1985 (U.S. Army Corps of Engineers 1984).

Prior to 1985, the most severe flood to hit Roanoke occurred in 1972. In late June, Hurricane Agnes dumped 6.3 inches of rain in four days on the Roanoke Valley. The Roanoke River crested around nine feet. Peak discharge within the city reached 24,300 cubic feet per second (U.S. Army Corps of Engineers 1984).

The flood of 1972 prompted governments in and around the Roanoke Valley to request a study by the Corps on alternative projects that would reduce flood risk. These alternatives included dams and local protection projects requiring the computation of flood control benefits for each project. After several years, the Corps proposed a 10-mile channelization of the Roanoke River within the city of Roanoke. In its final design, this project would widen the river channel, construct protective walls and dikes at several locations along the river, and install a flood warning system. The river channel improvements are designed to increase the capacity of the river to carry flood water (Roanoke Times and World News 1989; US Army Corps of Engineers, 1984). In a city of about 100,000 people the project would reduce the probability of flooding for only 2,265 single and multiple family residential structures. Also, the project would provide flood protection to about $250 million invested in businesses and industry employing about 5,000 people.

The worst flood suffered by the city of Roanoke occurred on November 4, 1985. It rained 6.6 inches in one day after raining four inches during the previous four days. The Roanoke River crested around 23 feet on the evening of the fourth, about two and a half times the crest height of the 1972 flood. Peak discharge topped 32,000 cubic feet per second. The City of Roanoke suffered an estimated $200 million in flood damages (Roanoke Times and World News 1989). It was the 1985 flood that motivated city officials to press for a construction of the Corps' channelization project.

The city was expected to provide $14.3 million dollars of the $34.4 million needed to build the project. Six million eight hundred thousand dollars of the city's share was provided by private land donations and other funding sources. A special single issue referendum was called April 11, 1989, asking voters to approve a $7.5 million bond issue to finance the City's remaining cash share of the Federal project's cost. The city-wide utility tax would be raised from 10 to 12 percent to repay the bond, increasing the average household's utility bill by approximately $2.00 per month. Because alternative flood reduction proposals were considered politically infeasible, rejection of the bond issue implied that the city would be without any flood protection measures for years to come.

The bond issue passed with over 56 percent support (4,271 to 3,273), with 19.6 percent of the registered city voters casting ballots.

3.2 The Roanoke Case Study Area

Of the residential neighborhoods exposed to flood risk, an area in southeast Roanoke was selected as the study site. The area consists of a small strip along the Roanoke river between Roanoke Memorial Hospital and the 9th Street bridge in southeast Roanoke. The area lies about a mile from the center of the city. In the western section of the neighborhood, the city owns all the property adjacent to the river. The properties in this section of the neighborhood are similar in terms of size of the lots and building structure. In the eastern section, the city owns all the land adjacent to the river except for a few properties. Part of the land adjacent to the river is a city park. In general, the properties closer to the river in this section of the neighborhood have smaller lots and smaller structures than property farther away from the river.

This study area was chosen over others in the city because of the area consisted of relatively homogeneous, well developed, and residential properties. The area is characterized by both a relatively dense clustering of homes and an absence of multiple unit dwellings (which were considered commercial property). In addition, the neighborhood had been completely developed for 40 years. Therefore no considerable future land use changes were expected to occur (Thunberg 1988). As shown in the following sections of this report, these neighborhood characteristics combined to simply the benefit estimation procedures, thereby making the comparison between techniques more straightforward.

The flood hazard reduction benefits were estimated for the properties in this area using the contingent valuation and the hedonic price methods (Thunberg and Shabman 1991; Driscoll, Dietz, Alwang 1994). The voting behavior in the single issue bond referendum of those living in the area were also collected and analyzed. In addition, the U.S. Army Corps of Engineers estimated residential flood control benefits using the property damages avoided method for all flood prone residential properties in the city of Roanoke as part of their Roanoke flood control feasibility report (U.S. Army Corp of Engineers 1984). From these four studies, all residential properties which had a complete set of flood reduction benefit estimates and voting behavior data were identified.[2] Thus, a common set of residential properties were generated in order compare benefit estimates. The results and implications of this comparison are presented in Sections 8 and 9 of this report.

[2] Thus there was a PDA estimate for parcel *X*, a CVM bid for the owner of parcel *X*, a land price difference for parcel *X*, and the voting behavior of the owner of parcel *X*.

SECTION 4
PROPERTY DAMAGES AVOIDED

Willingness to pay is the stated conceptual basis for benefit assessment outlined in the Water Resources Council's Principles and Guidelines (P&G). As a definition of social benefits, the willingness to pay rationale accepts the beneficiary's perception of the expected benefits of a good or service as the basis for benefit measurement. For flood control project services it is reasonable to expect that the subjective assessment would include both the property and nonproperty arguments of flood hazard reduction. The P&G also specifies the property damages avoided method (PDA) as the primary benefit measurement standard.

The purpose of this section is to describe the general PDA approach and to examine the strengths and limitations associated with the method. This section begins by describing the basic formulae for calculating property damages avoided. Next, the limitations of this method are outlined by examining the assumptions which are necessary to equate the expected value of property damages avoided measure with the conceptual willingness to pay standard. The validity of each PDA assumption and the consequences of violating these assumptions are discussed.

4.1 The Expected Value of Property Damages Avoided Formula

Under PDA, damages are defined as restoration and repair costs for damages to structural property and to household furnishings as well as the emergency costs borne by the landowner during the flood evacuation, reoccupation, and flood fighting. The amount of these damages resulting from any particular flood is assumed to be a function $h(x)$ of the flood level (i). Flood levels are probabilistic in nature and follow some density function $g(x)$.

The expected value of flood damages (ED) for a particular property occurring in one year for all flood levels is

[4.1] $$ED = \sum_{i=1}^{N} g(x_i)h(x_i)$$

where X_i represents flood i.[3]

Expected reduced damages from a flood control project are estimated as the difference between expected damages with the project and expected damages without the project. Because the project alters the probability of a flood occurring, the probability and damage functions change to $g^0(x_i)$ and $h^0(x_i)$ respectively for conditions with the project. The expected value of reduced damages (ERD) for one year is

[3] The X_i are ordered such that X_1 is the smallest flood possible that incurs property damage and X_n is the largest flood possible that has a greater than zero probability of occurring.

[4.2] $$ERD = \sum_{i=1}^{N} [g(x_i)h(x_i) - g^o(x_i)\,h^o(x_i)]$$

The present value of expected reduced damages, i.e., damages avoided, from a flood control project is calculated as the expected value of reduced damages from the project occurring over the planning horizon. Using the PDA method, the present value of reduced damages is the expected benefits (*PVEB*) of the flood control project. *PVEB* for an individual flood plain landowner may be expressed as:

[4.3] $$PVEB = \sum_{t=1}^{T} \left(\frac{\sum_{i=1}^{N} [g(x_{it})h(x_{it}) - g^o(x_{it})\,h^o(x_{it})]}{(1+r)^t} \right)$$

where the subscript t represents the tth year of the planning horizon which consists of T years the and r is the project discount rate.

Although Equation 4.3 is the formula used to calculate the flood hazard reduction benefits, a more general expression of benefits can be shown which takes risk attitudes into account. As will be explained below, risk assumptions in Equation 4.3 introduce important implications for the ability of PDA to represent willingness to pay. Explicitly accounting for risk attitudes, the expected present value of benefits can be written as:

[4.4] $$PVEB = \sum_{t=1}^{T} \left(\frac{(1+a_t)(\sum_{i=1}^{N} [g(x_{it})h(x_{it}) - g^o(x_{it})\,h^o(x_{it})])}{(1+r)^t} \right)$$

where a represents a measure of relative risk aversion for the flood plain occupant. Note that equation 4.4 is equivalent to equation 4.3 for $a = 0$, the risk neutral case, and that the expected present value of benefits for the risk averse agent, $a > 0$, exceeds that of the risk neutral individual.

4.2 Assumptions and Limitations of the PDA Method.

The PDA method has proven to be an enduring benefit estimation technique for several reasons. First, the PDA method relies on the hydrologic information that is routinely developed for project planning. Second, the PDA approach has a compelling investment logic: if current expenditures for a flood control project are less than the present value of avoided future repair costs then the project is justified.

However, the property damages avoided, as expressed by Equation 4.3, generates a measure of willingness to pay if the following assumptions are made:

1) Willingness to pay consists solely of reduced damages to the property owned solely by the landowner.

2) Only individuals living or owning property in the flood plain benefit from a

reduction in flood risk

3) Landowners possess the same discount rate as used by the project planner.

4) Landowners are risk neutral.

5) Landowners have the project planner's knowledge about the probability and consequences of certain flood events.

6) Landowners have made optimal flood plain investments given flood risk, wealth position, and general market conditions. Therefore, all damaged property would be fully replaced or restored following a flood.

7) Land market traders and flood plain occupants form subjective assessments of the worth of the flood reduction hazard on the same basis.

Clearly, it is likely that one or more of the underlying assumptions needed to equate the PDA estimate of residential flood control benefits to the conceptual model of willingness to pay presented in Section 2 will be violated. The question of interest is what are the consequences for the PDA method of relaxing any of these assumptions? The following discussion will examine each of the assumptions needed to ensure the compatibility of the PDA method with the conceptual willingness to pay standard by assessing each assumption separately, holding all other assumptions valid.

The first assumption is based on the fact that only the property arguments of flood hazard reduction are included in the computation of damages. The conceptual model developed in Section 2, however, suggests that flood plain residents may consider a flood control project as a means to reduce pre-flood anxiety, post-flood trauma, or community disruptions. The reduction of emotional or psychological stress stemming from flood related anxiety or trauma could be considered an important nonproperty benefit by flood plain residents. Furthermore, citizens may be willing to pay for flood reduction projects in order to maintain the cohesion and stability of their communities. If flood plain residents value these personal and neighborhood nonproperty effects, then the exclusion of these arguments will under represent a landowner's total willingness to pay for a reduction in flood risk.

The first assumption also implies that only beneficiaries of a reduction in flood risk are those living or owning in the property in the flood plain, i.e., assumption number 2. Yet, citizens in the community who are not directly affected by the flood hazard, may place a positive value on the construction of a flood control project out of sense of civic or moral responsibility. To the extent of such "civic" benefits exist, PDA will under represent the total "community's" willingness to pay for flood risk reduction.

The third assumption maintains that each landowner possesses the same discount rate as the project. If the discount rates differ, the present value of expected benefits, as calculated by equation (4.3), will differ from the potential wealth change of the landowner. The estimated benefits will

misstate landowner willingness to pay, but the extent and direction depend on the difference between the project and landowner's discount rates.

The PDA also assumes that all landowners are risk neutral, assumption number 4. For a risk neutral individual, $a = 0$, and Equation 4.4 is equivalent to Equation 4.3. Risk neutrality is assumed because it is consistent with the expected value rules and the use of avoided property damages as a measure of flood control benefits.

If a landowner is not assumed to be risk neutral, then he is risk averse.[4] The risk averse landowner would be willing to pay what the risk neutral individual would pay for flood protection plus an amount equal to the money value of the gain in utility over and above property protection. As a result, the PDA only measures the willingness to pay of the risk neutral landowner while providing only a lower limit of what the risk averse individual is willing to pay. To see this, recall that for the risk neutral case where $a = 0$, Equation 4.4 is equivalent to the expected value of property damages avoided. For any value of $a > 0$, the risk averse case, Equation 4.3 will under represent the computed value of benefits.

What are the possible sources or explanations of risk averse attitudes? It seems reasonable to suggest that risk averse behavior is triggered by anxiety about characteristics of particular types of situations. Fischoff *et. al.* (1976) identified several anxiety creating factors that are likely to trigger a risk averse response. The situational characteristics found to score high in creation of anxiety were those that were involuntary, delayed, uncontrollable, unknown, unfamiliar, severe, and potentially catastrophic. The majority of these characteristics are common to flood risk. Thus, the risk neutrality assumption is likely to be violated and willingness to pay will not be fully represented by avoided property damages.

The fifth assumption requires that all landowners have the same perception as the project planner of the likelihood and consequences of various flood events. In terms of Equation 4.3, this assumption implies that $g(x)$ and $h(x)$ are known by occupants of the flood plain. In short, it is assumed that people hold "objective," not subjective, probabilities concerning flood risk. Such an assumption is likely to overestimate the average individual's capacity to acquire and evaluate flood related information because the acquisition of flood information is not costless and because of infrequent trials limit experience, i.e. flood events of varying magnitude are relatively rare. Furthermore, all individuals will not possess equal means to obtain information nor be equally capable of evaluating such information. At best, individuals possess imperfect understanding of the likelihood and consequence of flood events. As a result, each individual must form his own subjective assessments of the probability and consequences of floods of different magnitudes. If individuals do not utilize the planner's information about flood events and compile that information in the same fashion as the planner, then the computed expected value of property damages of the planner and flood plain resident will be different. How the planner's and flood plain occupant's assessment of the probability of flooding differs, however, is unknown without information on the flood plain occupant's perceived values of $g(x)$ and $h(x)$.

[4] As explained in Section 2, risk seeking is not considered a realistic assumption in the case of flood risk.

The PDA method also assumes that individuals have made optimal and permanent flood plain investments given flood hazard, wealth position, and general market conditions. Furthermore, the factors that define optimal investment such as preferences, interest rates, wealth, income, and relative prices are assumed to remain stable over time. This stability assumption implies that all structural investments would be replaced or restored to their pre-flood existing condition. However, the factors that determine the landowner's investment choices will change over time. This change could result in a change in the investment patterns resulting in a future land use different from the current use. Thus, the benefits estimated will misstate landowner willingness to pay by some unknown magnitude.

For the PDA method to measure willingness to pay, all of the preceding assumptions must hold, plus the land holders must expect to be fully compensated for their willingness to pay bid by the land market if they relocate off the flood plain. Only in this manner can they be assured that the payments made for flood protection will be equal to the benefits received either in the form of flood protection or in the form of money compensation from the sale of the land parcel. For the land market to assure that this expected compensation will occur, assumption number seven must hold. That is, it must be assumed that not only the current flood plain occupant but also all others who will trade in flood plain parcels base their subjective assessment of the worth of a flood hazard reduction strategy on the same considerations as the PDA method assumes for the current landowner.

Again, the importance of these seven assumptions is to insure that the PDA techniques will accurately estimate willingness to pay. As the above discussion demonstrates, several of the PDA assumptions are likely to be violated. If a survey of flood plain residents were conducted one could expect to find that most individuals would display characteristics that would lead to the rejection of one or more of these assumptions. Only when assumptions 1, 2, and 4 are violated is it possible to reasonably know whether PDA will over or under represent total willingness to pay. However, if only assumptions 1, 2, and 4 are violated, PDA will not fully reflect total willingness to pay.

4.3 PDA Estimates for the Roanoke Case Study

The U.S. Army Corps of Engineers (1984) used the PDA method to estimate the residential flood hazard reduction benefits attributable to Roanoke's proposed flood control project. The PDA estimates for the residential properties in the Roanoke study area were obtained from the Corps' Wilmington District Office. These estimates are reported and discussed in Section 8.

SECTION 5
THE HEDONIC PRICE METHOD (LAND PRICE ANALYSIS)

A land transfer price represents an agreement between willing buyers and sellers on the worth to them of a land parcel. There are numerous factors that may enter into the trader's subjective valuation of a given land parcel including lot size, house size, and the condition of adjacent parcels. Flood risk maybe another factor traders consider when buying and selling land.

Land price analysis, technically termed hedonic price analysis, statistically relates the property price to a set of housing characteristics in order to separate the property price effects of flood risk from other housing characteristics. Under appropriate circumstances, these models can be used to both accurately "separate" the value of each characteristic and directly estimate the consumer's willingness to pay for changes in each characteristic. If these conditions are met, benefits derived from a flood control project are estimated as the increases in property prices due to the change in flood risk. The difference in the prices of properties with identical characteristics but differing degrees of flood risk represents the present value of the difference in flood risk, discounted by an interest rate deemed appropriate by the land market traders. Since property as well as nonproperty arguments related to flood risk may enter in land market traders' subjective property assessments, property and nonproperty concerns could be reflected in the total benefit figure.

Numerous studies have used land price analysis to examine the impact of different levels of flood risk on land prices. Some studies using this method have related the effects of flood control projects on property values but did not estimate benefits from reduced flood risk (Struyk 1971; Soule and Vaughan 1973; Shabman and Damianos 1976; Babcock and Mitchell 1980; Park and Miller 1982; Donnely 1989; and Tobin and Montz 1994). In other studies, benefits from a reduction in flood risk were estimated using the hedonic approach (Maxwell and North, 1974; Senjem and Freshwater, 1981; and Thompson and Stoevener, 1983).

This section begins by describing the basic land price analysis method and how it can be used to generate benefit estimates. Next, the assumptions and potential limitations of the land price analysis are noted, including a general discussion of the conditions in which land price differences can generate estimates of willingness to pay. Finally, the empirical land price model used to generate benefit estimates for the Roanoke study is described.

5.1 The Hedonic Price Method

The process of using the hedonic price model to estimate willingness to pay for flood reduction benefits can be thought of as a two stage process. During the first stage, a hedonic model is specified and statistically estimated to determine the characteristics that affect property prices. This stage estimates the implicit dollar contribution of reduced flood risk to the total price of the property. In the second stage, the estimated value of reduced flood risk from the land price equation is then multiplied by the amount the flood control project is expected to reduce that risk to arrive at a total benefit measure. It should be noted, however, that this process will yield valid willingness to pay estimates only under certain conditions which will be reviewed below.

The land price analysis begins by specifying a model that relates property price with its characteristics. Property, which can be defined as a plot of land and any structures on the plot, is not a homogeneous good but one characterized by different combinations of attributes. Furthermore, these individual attributes generally cannot be separated from the property itself and traded in markets as separable goods. Brigham (1965) was one of the first researchers to use regression methods to determine how different property characteristics affect prices. For residential properties in the Los Angeles area, Brigham assumed that the value of residential property is "functionally related to its accessibility to economic activities, to its amenities, to its topography, to its present and future use, and to certain historical factors that affect its utilization" (p. 325). Studies that followed, like Ridker and Henning (1967), Struyk (1971), Soule and Vaughn (1973), Maxwell and North (1974), Shabman and Damianos (1976), Babcock and Mitchell (1980), Diamond (1980), Li and Brown (1980), Senjem and Freshwater (1981), Park and Miller (1982), Thompson and Stoevener (1983), Palmquist (1984), and Donnely (1989) regressed similar explanatory variables on property prices to determine the effect of an amenity of interest.

From these studies, the different characteristics that have been found to affect property prices can be categorized under four general headings: (1) property characteristics, (2) neighborhood characteristics, (3) accessibility to nonresidential activities, and (4) market conditions (Dietz 1992). The market clearing price of property i can therefore be defined by the hedonic property price function as:

[5.1] $$p_i = P(C_{1i},...,C_{mi}, N_{1i},...,N_{mi}, A_{1i},...,A_{mi}, M_{1i},...,M_{mi})$$

where $C_{1i},..,C_{mi}$ are the property characteristics associated with property i,
$N_{1i},..,N_{mi}$ are neighborhood characteristics associated with property i,
$A_{1i},..,A_{mi}$ are accessibility characteristics associated with property i,
$M_1,..,M_m$ are general market conditions, and
p_i is a market clearing price based on supply and demand conditions.

Property characteristics (C_i) refer to the characteristics of the property itself that are deemed of worth by the buyers and sellers. Property characteristics could include the age, construction, and size of the building as well as the size of the lot. The level of flood risk can also be considered a property characteristic.

In addition to property characteristics, the characteristics of the neighborhood (N_i) in which the property is located may influence the price agents are willing to pay for a particular property. For instance, given the choice between identical homes in a high crime neighborhood and low crime neighborhood most people would be willing to pay a higher price for the house in the low crime area. Besides crime rates, other variables such as housing density, median neighborhood income, vandalism, and the quality of schools have all been used to as measures of neighborhood quality (Li and Brown 1980; Diamond 1980; and Palmquist 1984).

Theoretically, property with easier access to nonresidential activity is of higher value than property without similar ease. Two indicators of accessibility (A_i) suggested by Li and Brown (1980) and Diamond (1980) are proximity to nonresidential activities and proximity to residential activities and accessibility to major roads. The further a landowner must travel to a nonresidential

activity, such as a shopping mall, place of work, or a park, the more he or she expends in time and money. Thus, a landowner who owns property closer to places of nonresidential activity saves both time and money, hence, the value of the property should be greater than those without similar proximity, holding all other characteristics constant. However, if the property is too close to a place of nonresidential activity, the value of the land may decrease due to the disamenities produced by traffic and noise. Similarly, if a landowner can quickly get to a major road, his or her travel time and costs decrease. Therefore the value of the property should be greater than those properties without similar access, holding all other characteristics constant.

When observations on prices and characteristics occur over time, it becomes important to measure changes that may affect supply and demand conditions for properties from year to year. These market changes (M_i) affect the utility gained from the property and thus cause changes in property prices. These characteristics, which include unemployment rates, mortgage rates, and population, may play an important role in measuring these changes. Other factors that may affect market conditions are changes over time in the centers of nonresidential activity and the attributes that determine neighborhood quality.

Once the characteristics that impact property prices have been identified and quantified as measurable variables, regression analysis is used to estimate the effect each characteristic has on property price. Taking the first derivative of p_i in Equation 5.1 with respect to any given characteristic is interpreted as the marginal implicit price of that characteristic measuring the additional expenditure required to obtain a property with one more unit of the given amenity, holding all other characteristics constant.[5] Assumed to be price takers in the land market, each household faces a set of these implicit marginal price schedules for the various housing characteristics. If households are further assumed to be a utility maximizing units and in equilibrium, the marginal implicit price of a given amenity that has been chosen is equal to the marginal willingness to pay for that characteristic (Freeman 1979).

Once an appropriate regression model has been estimated, the second step is to estimate flood hazard reduction benefits. To determine the amount a consumer is willing to pay for an increase in flood risk reduction of the property given a marginal change in flood risk, the estimated value of the property from the hedonic model is calculated given the new and old flood zones, i.e., changes in flood zone qualification for the with versus without project conditions. From the estimated hedonic property price model, the difference between estimated property prices with the old and new flood risks is defined as the benefit derived from the amount of flood risk reduction associated with the flood control project.

5.2 Limitations and Assumptions of the Hedonic Price Method

Unlike the PDA method, one of the primary advantages of the hedonic price method is that

[5] For a linear specification of Equation 5.1, the implicit price of any given variable, i.e., characteristic, would simply be the regression coefficient associated with that variable. The implicit price would also be constant in a linear model. In a non-linear specification of Equation 5.1, implicit prices would be dependent on the quantity of the characteristic being consumed.

benefit estimates are derived from revealed market behavior of land traders. Since land prices are the result of the subjective assessments of land market traders, nonproperty as well as property benefits associated with reduced flood risk would be reflected in the hedonic estimates. Furthermore, no assumptions about individual risk attitudes, personal discount rates, and the existence of objective probabilities are needed. Yet, the fact that the hedonic method relies exclusively the subjective assessments of flood risk by land traders to generate benefit estimates introduces several potential problems.

Hedonic price analysis can only generate benefit estimates for landowners in the flood plain. If the threat of flooding does not exist at the property or neighborhoods of other landowners, their property prices will not be affected by the construction of the flood project. Yet many nonflood prone residents may value the benefits of a flood control project for civic reasons and be willing to pay to help build a flood control project. If these civic concerns for flood risk reduction exist, they cannot be captured using hedonic pricing models.

Although the hedonic price technique allows for the possibility of estimating both property and nonproperty benefits for flood prone landowners, the method does not offer a manner to distinguish the contribution of property and nonproperty arguments to the final benefit estimate. Furthermore, the hedonic price method also fails to provide any insights into the individual's risk attitudes, personal discount rate, or information and understanding about the flood risk.

The lack of any evidence into the land trader's subjective assessment of the flood risk is particularly troublesome, since the land trader's understanding of the probability of flooding may diverge significantly from the planner's knowledge. Flood events occur relatively infrequently, and since individuals form many perceptions based on personal experience, the potential exists for individuals to underestimate the probability of given flood event from occurring (Kask and Maani 1993).[6] In addition, some research has found that people tend to assign zero probabilities to natural disaster events with a low objective probability of occurrence (Slovic *et. al.* 1977; Schoemaker and Kunreuther 1979). Furthermore, technical information about the risk of flooding may be difficult and costly to obtain, or of such a complex nature that even the acquirement of such information may fail to impress the individual's perception of the flood risk. Therefore, the hedonic price method is not capable of distinguishing an unawareness about the risk of flooding from an unwillingness to pay for flood protection.

Reliance on land market transactions introduces a built-in incentive system to restrict the flow of information that is known. In an environment where buyers and sellers have perfect information regarding the level of flood risk, the price of a property subjected to period flooding will be depressed in direct relation to the magnitude of the flood risk. Yet, buyers and sellers in the land market are not likely to possess the same level of information about the frequency of flooding or the magnitude of damages associated with a flood event. Sellers may have direct experience and knowledge of the consequences of flooding on property, psychological well-being, and their neighborhood. Buyers are unlikely to possess this information. Since the exposure of the property

[6] Likewise, an unusual number of floods occurring in a relatively short time span may lead individuals to overestimate the probability of a given flood event.

to flood risk will be a factor in depressing property prices, the seller has a direct financial interest not to fully reveal the severity of the flood risk to the buyer. To the extent information about flood risk is lost or withheld in the land market, hedonic price analysis will under represent the total willingness to pay for flood risk reduction.

In addition to the above limitations, there are several potential technical difficulties that maybe encountered in benefit estimation process. Specifically, several technical assumptions and data constraints limit the ability of hedonic price analysis to accurately separate property attributes in the hedonic price equation, step 1, and to generate theoretically valid benefit estimates, step 2.

In order to interpret the marginal implicit prices derived from the hedonic price function as a household's marginal willingness to pay for a particular amenity several theoretical conditions are necessary, including the assumption that households and housing markets are in equilibrium. To ensure this equilibrium, the following assumptions are also made (1) households are assumed to possess full information about housing prices, (2) the transaction and moving costs are zero, and (3) implicit prices adjust instantaneously to changes in supply and demand. Of course, most of these assumptions never hold in real world land markets. Freeman (1979) argues that in many instances, divergences from these assumptions will result in changes in willingness to pay.

In addition to these theoretical assumptions, the housing market data may prevent a valid hedonic price model from being estimated. First, there must be sufficient variation in property characteristics among the sampled observations in order to properly estimate a hedonic price equation. The smaller the variation in characteristics the greater the potential error in the model's implicit price estimates. Second, several problems may rise from the use of cross-sectional data to estimate the hedonic price equation. When the affected urban area is large relative to other urban areas and where household mobility is restricted to the affected area, property prices at any location depend on the amenity levels throughout the urban area. Then the hedonic property price function cannot be used in a direct way to predict the overall pattern of changes in property values from an amenity shift that affects an entire urban area. Polinsky and Shavell (1974; 1976) determined that when the affected urban area is small relative to other nearby areas and where household mobility between the urban areas is costless; then property prices at any location depend only on the amenity levels at that location and cross-sectional data can be used to estimate the hedonic price function.[7]

Even if a proper hedonic price model can be estimated, the results cannot always be used to generate a measure of willingness to pay (step 2). Conceptually, hedonic price model generates only marginal implicit prices of the characteristic in question. If a flood control project results in a nonmarginal change in flood protection, the use of the marginal implicit price of flood hazard reduction to generate benefits estimates would overestimate total willingness to pay for the change. The theoretically appropriate measure of benefits of a nonmarginal change would involve estimating an inverse demand function, or willingness to pay, function for the amenity of interest and calculating the total consumer surplus stemming from the change. Given data limitations

[7] For a review of these data limitations see Freeman (1979) and Dietz (1992).

inherent in the hedonic price technique, however, estimating a demand function for a given amenity is generally not possible.[8]

5.3 The Roanoke Hedonic Price Study

Flood hazard reduction benefits were estimated for the Roanoke study area using the hedonic price method by Dietz (1992) and Driscoll, Dietz, and Alwang (1994). The results of the estimated hedonic price model were then used to estimate flood hazard reduction benefits for the residential properties in the study area. The general description of the variables used to estimate equation 5.1 and the procedures used to generate benefit estimates are reported in this Section.

5.3.1 Sample, Variable Definition, and Model Specification

Each property in the City of Roanoke has been assigned a tax map number for a variety of uses. From the set of tax map numbers of the properties in the study area, computer printouts describing the properties were obtained from the Office of Real Estate Valuation for the City of Roanoke. These printouts revealed the age and other physical conditions of the structure and the last few sale dates and sales prices of each property. When the transaction data was omitted or illegible, the missing data was obtained from the original deeds from the Grantor and Grantee Indexes available in the vault of the Office of the Clerk of the Circuit Court.

To supplement and verify the transactions data obtained from the printouts, photocopies of the tax map records provided by the Office of the Commissioner of the Revenue were examined. These copies showed the transaction history of each property dating back to at least 1980 or the year in which the structure was built. In addition, a parcel-by-parcel examination of the permanent card file of the Office of Real Estate Valuation was undertaken to provide information concerning improvements or additions made to each parcel over the years.

In this study, the sample consists of study area property transactions that were sold at fair market prices between 1980 and 1990. In some cases, observations were removed because the property prices did not reflect the present value of the benefit stream generated from owning the property. For example, transactions due to inheritance or divorce settlements were not included in the final sample. Properties that were damaged in the 1985 flood and sold unrepaired were also removed from the sample. After these adjustments, the final sample contained 99 observations.

Because this study utilizes time-series data, the property prices are deflated to make the observations comparable over time. The property prices in this study are deflated into 1990 dollars using the monthly consumer price index for shelter expenditures. This index is a weighted average of current and new residential property mortgages and rent. The resulting variable, *PRICE*, is the dependent variable used in the hedonic model.

[8] Although a demand function usually cannot be estimated from available data, measures of willingness to pay and willingness to accept for nonmarginal changes may be derived under certain conditions (see Dietz 1992 and Driscoll, Dietz, and Alwang 1994).

As the above discussion states, the set of independent variables in Equation 5.1 can be can be categorized under four general headings: (1) property characteristics, (2) neighborhood characteristics, (3) accessibility to nonresidential activities, and (4) market conditions (Dietz 1992). Two of these general categories: neighborhood characteristics and accessibility to nonresidential activities, were not needed in this study. Because the study area is compact relative to the city, every property in the study area is approximately the same distance from any major nonresidential activity. The value generated from the property's accessibility to the major nonresidential activities and roads will be identical for each property. Therefore no accessibility characteristic were used in the hedonic model. Similarly, neighborhood characteristics have no effect on property price differentials of properties in the same neighborhood. Therefore, no neighborhood characteristics were used in the hedonic model in this study.

Due to the homogeneity of the accessibility and neighborhood characteristics of the study area, only the property characteristics of each property will explain the cross-sectional variations in the property price of the properties. At any point in time, the following desirable property characteristics are expected to have significant positive effects on property price differentials:

ACREAGE: the acreage of the lot,

LIVEAREA: the square footage of the structure,

BATHFIX: bathroom equivalents (bathroom fixtures),

USE: whether the property is zoned for single or multi-family use (single family use = 1, otherwise 0),

CONST: whether the exterior is of brick/stone construction or not (brick/stone = 1, otherwise 0), and

PARK: whether the property is adjacent to the park in the neighborhood (adjacent = 1, otherwise 0).

The property characteristic of interest in this study is flood risk. Because the flood zones of the properties in the data set are available from the Corps, flood risk is measured in terms of the flood zone *(FZ)* of the property. Flood zone *(FZ)* is defined as the minimum flood event which will result in damage to the property. Thus, a property in the 100 year flood zone will be flooded only by a 100 year flood or greater, where a 100 year flood is the flood flow that has a 1 percent chance of occurrence in any year. Thus the higher the flood zone, the lower the risk of the property flooding. All parcels were grouped nine flood zones: 10, 15, 20, 25, 30, 50, 100, 500, and 1000 year flood zones. The flood zone *(FZ)* is converted into the variable flood freeness *(FZONE)* which is defined as the percent chance of not being flooded in a given year and calculated as

[5.2] $$FZONE = 1 - \frac{1}{FZ}$$

Since property price and property characteristic data are taken over an eleven year time period (1980-1990) various regional market conditions are still needed to control for changes in the supply and demand conditions. But observations for most of these characteristics are unrecorded. In this instance, annual dummy variables, *DUM80*, *DUM81*, . . . , *DUM89*, are used to control for and proxy annual market conditions. These variables take on a value of one if the property was sold in the appropriate year and a value of zero otherwise.

The general hedonic model used to define property prices in the Roanoke study is therefore specified as:

[5.3] $$PRICE = f(ACREAGE, LIVEAREA, BATHFIX, FZONE, CONST, USE, PARK, \mathbf{DUM})$$

where $\mathbf{DUM} = (DUM80, DUM81, ..., DUM89)$.

5.3.2 Hedonic Price Model Estimates

As noted above, when the area by a flood control project is small relative to other nearby areas and where household mobility is costless, the hedonic property price function can accurately forecast the price effects of a change in flood risk. In the City of Roanoke, the areas affected by the change in flood risk represents only a small portion of the properties in the city. Therefore, the hedonic model should be able to forecast property prices (Dietz 1992).

A Box-Cox model was used to estimate Equation 5.3. Housing price *(PRICE)* and all continuous independent variables *(ACREAGE, LIVEAREA, BATHFIX, FZONE)* underwent the same Box-Cox transformation. Using a grid search, and a model with a Box-Cox parameter λ = 0.05 produced the best fit. This λ value produces a model similar to a log-log specification.[9]

In the process of estimating the Box-Cox model, a structural change was identified in the model between the 1980-1985 period and the 1986-1990 period. The split in these two time periods is marked by the November 1985 flood. The structural change indicates that the 1985 flood had a significant effect on changing land market traders' perception of flood risk. To model this structural change two new flood risk variables *(FZONE1,FZONE2)* are created from the original flood freeness variable *(FZONE)*. The new flood risk variables are defined as follows:

FZONE1: takes the value of *FZONE* for all observations between 1980 and 1985 and a value of 0 from 1986 to 1990.

FZONE2: takes the value of 0 for all observations between 1980 and 1985 and the value of *FZONE* from 1986 to 1990.

[9] The model was estimated using a two-stage least squares approach. For a discussion see Driscoll, Dietz, and Alwang (1994).

In essence, the *FZONE* variable was separated into two variables, with *FZONE1* measuring the influence of different levels of flood risk on property values prior to the 1985 flood and *FZONE2* measuring the influence of flood risk after 1985. After this structural change was modeled, the hypothesis of no structural change could not rejected.[10]

The final regression results for the Box-Cox hedonic price model are presented in Table 5.1 and have been previously reported in Driscoll, Dietz, and Alwang (1994). All variables are of the expected sign. Of particular relevance to this report are the coefficients of *FZONE1* and *FZONE2*. The *FZONE2* variable was statistically significant and positive, indicating that land traders after 1985 were willing to pay higher prices the higher the probability that the property would not be flooded, holding all other factors constant. The coefficient of *FZONE1*, however, was very close to zero and statistically insignificant. This implies that the location of residential properties in the flood zone did not have a significant impact on land prices prior to 1985. From these results, it appears that the 1985 flood focused traders' attention on the previously unacknowledged flood hazard.

Willingness to pay for a flood control project depends on an individual's perceptions about flood risk and changes in flood risk. For landowners in the study area, the hedonic property price function for the time period 1980-1985 implied that land buyers were indifferent to a property's flood risk as defined by the flood zone. However, after the November 1985 flood, land buyers became more aware of flood risk as demonstrated by the hedonic property price function for the time period 1986-1990. Although the threat of flooding has always existed, if the hedonic study had been done prior to the 1985, the conclusion would have been that there were no benefits to flood protection.

5.3.3 Estimating Willingness to Pay From the Hedonic Model

A flood control project reduces the probability that properties in the flood plain will be damaged in a flood event. Using data from the U.S. Army Corps of Engineers (1984), the change in flood zones resulting from the project construction was calculated by Dietz (1992). The new flood zones are shown in Table 5.2 below. For example, a property in the 30 year flood zone prior to project construction would only be damaged by a 100 year flood after the project is constructed.

The amount property owners would be willing to pay for a reduction in flood risk provided by the project is the increase in property values stemming from the reduction in flood risk. The hedonic equation is used to estimate the impact of the change in flood risk on property values for each parcel in the study area. The new flood zone data listed Table 5.2 were used to generate the probabilities of flood freeness with the project using Equation 5.2. Thus the values of *FZONE2* were recalculated under project conditions. The difference between the observations of *FZONE2* before and after the project is the measure of flood freeness provided by the project, i.e., the

[10] For a detailed discussion of how this model was specified see Driscoll, Dietz, and Alwang (1994).

reduction in flood risk.[11] Along with the house and lot characteristics of each property, the calculated change in flood risk was substituted into the hedonic price equation to generate an estimate of the change in property value due the reduction in flood hazard. The difference in the estimated property values with and without the project is the hedonic benefit for a reduction in flood risk. Benefit estimates generated using this procedure for the properties in study area are reported in Section 8 of this report.

Table 5.1: Regression Results for Box-Cox Hedonic Price Model ($\lambda = 0.05$)

Variable	Parameter Estimate	Standard Error
INTERCEPT *	11.699	1.702
ACREAGE *	1.454	0.531
LIVEAREA *	0.499	0.172
BATHFIX	0.406	0.244
CONST	0.238	0.122
PARK	0.471	0.243
USE *	0.510	0.199
FZONE1	0.188	3.620
FZONE2 *	8.440	3.389
DUM80	0.194	0.248
DUM81	- 0.261	0.275
DUM82	- 0.174	0.262
DUM83	0.130	0.245
DUM84	0.161	0.291
DUM85	- 0.263	0.288
DUM86	- 0.199	0.238
DUM87	0.244	0.241
DUM88	- 0.116	0.268
DUM89	0.160	0.257

* = Statistically significant at the 0.05 level of significance

[11] Since the flood control project virtually eliminated the possibility of flooding in the old 500 and 1000 year flood zones, properties beyond the 1000 year flood zone were assigned a new *FZONE2* value of 1 indicating the property to be essentially "flood free."

Table 5.2: Flood Zones With and Without the Flood Control Project

Old Flood Zones	New Flood Zones[12]
10	33
15	45
20	63
25	77
30	100
50	167
100	333
500	*
1000	*

[12] Given the Corps' proposed flood control project, the properties in the 500 and 1000 year flood plains are removed from the standard project flood area and therefore have no corresponding flood zones.

SECTION 6
THE CONTINGENT VALUATION METHOD (CVM)

As demonstrated in the previous two sections, several potential conceptual and theoretical barriers limit the ability of the PDA and hedonic price methods to measure willingness to pay. Since PDA is ultimately derived from technical hydrological data sources, the PDA method must make a variety of restrictive assumptions about individual decision making. Furthermore, PDA focus is exclusively on the property effects of flooding, ignoring all nonproperty effects. In contrast, the hedonic price method relies exclusively on the information and understanding of land traders about the level of flood risk to generate benefit estimates. The contingent valuation method (CVM) is a survey-based method that avoids all the limitations surrounding PDA and the hedonic price method by generating benefit estimates taken directly from the individual (Cummings, Brookshire, Schulze 1986).

This section begins by reviewing the basic components of a CVM study. The potential limitations and criticisms of this method to generate meaningful estimates of willingness to pay are also reviewed. Next, a description of how the CVM was used to estimate flood reduction benefits in the Roanoke study area is given. The construction, administration, and results of the survey are presented. The results contain a summary of the willingness to pay bids (WTP bids) elicited as well as a statistical analysis of what factors were significant in determining an individual's WTP bid. The statistical analysis tests the relative importance of property and nonproperty arguments in a landowner's stated willingness to pay for a flood control project.

6.1 The Contingent Valuation Method

Although the Water Resources Council's P&G conceptual benefit standard is willingness to pay, PDA and the hedonic price methods must infer estimates of willingness to pay from projected property damages and land price differences. The basic approach of the CVM is more straightforward: simply ask people what they are willing to pay to either receive a given increment or to avoid a given decrement of a particular nonmarket good. The individual's response is conceptually identical to the willingness to pay rationale put forth by the P&G referred to in Section 1 and microeconomic choice theory presented in Section 2. The CVM has received wide application in valuing a variety of nonmarket goods such as, wildlife (Bowker and Stoll 1988; Stephenson and Taylor 1989; Samples and Hollyer 1990; Reaves 1993; Boyle *et. al.* 1994), air quality (Rowe *et. al.* 1980; Randall *et. al.* 1974), water quality (Strand et. al, 1985), scenic views (Boyle and Bishop 1988), risk (Krupnick and Cropper 1992), and the value of recreational sites (Loomis 1989; Boyle, Welsh, and Bishop 1993). While conceptually applicable to an entire range of public and nonmarket goods, the CVM has not yet been used to estimate flood control benefits.

A questionnaire is designed to elicit an individual's willingness to pay for the nonmarket good of interest. A CVM questionnaire is administered either through a mail survey, telephone interview, or personal interview. The essence of the contingent value survey lies in the construction of the hypothetical market. A hypothetical market, or contingent scenario, is created for the nonmarket good and the individual is asked to value the good within that context. The contingent scenario is made up of three components: 1) the description of the commodity to be valued, 2) a description of the contingent market, and 3) the payment vehicle. First, the respondent is given a

description of the nonmarket commodity to be valued. The change in the commodity must be clearly defined and consistent with what the analyst is attempting to measure. The description of the contingent market follows. The contingent market defines the market participants, the rights and obligations of the participants, and the terms and conditions under which the commodity is provided. The payment vehicle defines how the commodity or commodity change is going to be paid for. Examples of potential payment vehicles include a tax, private preservation fund, user fees, or license.

After the complete contingent scenario is provided the survey respondent then is asked what he or she is willing to pay for the proposed commodity or commodity change just described. This is called a "WTP 'bid'". The willingness to pay question can be asked in three general formats: open-ended, payment card, or dichotomous choice. An open-ended question simply asks the respondent how much he would be willing to pay for the given commodity. The payment card method presents the respondent with a range of possible WTP bids and then the respondent is asked to pick from the range of values. Finally, the dichotomous choice format asks the respondent whether they would be willing to pay X amount of dollars for a given commodity. The respondent is confronted with one WTP bid, selected at random, and answers with a "yes" or "no" response.

From socio-economic and personal characteristic data also obtained in the survey, a bid function is then estimated from the sample in order to model the WTP decision. This bid function can then be used to derive a benefit estimate for the general population. Unlike the hedonic price method, the CVM depends on observations created by a hypothetical situation and not actual choice behavior to generate benefit estimates.

6.2 Assumptions and Limitations of the Contingent Valuation Method

There are several advantages of using the CVM to value nonmarket commodities. The CVM is conceptually able to capture nonproperty as well as property benefits associated with a reduction in flood risk. Furthermore, unlike either the PDA or hedonic price method, the CVM is not confined to measurement of flood risk reduction benefits to only flood plain residents. Although not examined in this study, the CVM could certainly ask residents living and working outside the flood plain what they would be willing to pay for flood risk reduction. Thus, the CVM is the only benefit estimation technique examined in this study conceptually capable of estimating entire range of property and nonproperty benefits.

Like the hedonic price method, but unlike PDA, the CVM does not impose any assumptions about an individual's risk attitudes, personal discount rates, or level of flood risk knowledge. However, recall that the hedonic price benefit estimates are totally dependent on landowners' subjective understanding of the flood risk. The CVM can overcome the potential lack of any information a flood plain resident may have about the probability and consequences of flooding. In the description of the contingent market, the CVM provides information to the survey respondent about the nature of the good being valued. In the case of valuing a reduction in flood risk, the CVM questionnaire could provide information about the objective probability of flooding. While there is no guarantee the individual will interpret this information in an "objective" manner, it does guarantee the individual is not ignorant about the level of flood risk.

There are, however, numerous limitations associated with the CVM method itself. These are referred to as sources of biases in the CVM literature. In general, the biases associated with CVM can be grouped into two general categories, survey biases and motivational biases.[13] Each of these biases can result in changes in willingness to pay without changing the commodity being valued.

One group of biases, survey biases, is related to the structure of the survey itself. Biases can occur with any of the three components of the contingent scenario described above. The quantity and quality of information provided in the commodity description has been found by some researchers to significantly influence respondent's WTP bids (Samples, Dixon, Gowen 1986; Bergstrom and Stoll 1987; Boyle 1989). How the commodity is proposed to be paid for, i.e., tax, user fee, or private contribution, could also influence an individual's bid, holding all other factors constant. For instance, a respondent may place a high value on the nonmarket good that is being described but object to an increase in taxes as a way to pay for the good. In addition, how the WTP question is asked could alter the value a respondent places on the commodity (Boyle, Welsh, and Bishop 1985; Johnson, Brengenzer, and Shelby 1990; Kealy and Turner 1993). Finally, the selection of the format of the survey itself, either mail, telephone, or personal interview, may affect WTP bids (Mitchell and Carson 1989). The choice of survey formats could give rise to other biases. If a mail questionnaire used, selection bias becomes a potential problem. Unlike telephone or personal interview, people receiving a mail CVM study can examine the subject matter then choose not to participate, potentially biasing the sample.

Besides the biases surrounding the survey itself, motivation biases deal with the disposition of the respondent prior to or during the interview process. The most important forms of motivational bias are hypothetical and strategic bias. Hypothetical bias can be a problem whenever the respondent is unfamiliar with the contingent scenario or does not believe the contingent scenario will occur. Under either of these circumstances, the respondent may not be motivated to seriously consider the CVM scenario and give a thoughtful bid. This bias implies that people do not react to the survey the same way they would to an actual market situation (Bishop and Heberlein 1986). The effect of this bias can be minimized however, by constructing a realistic and familiar contingent scenario.

Strategic bias occurs when a respondent states a false bid in an attempt to influence the outcome of the contingent value survey (Cummings *et al.*, 1986). Respondents may behave in a strategic manner whenever they believe their bid will affect whether or not the commodity will be provided and/or the price at which the commodity is offered. Because the possibility of strategic behavior is likely to increase as the contingent scenario becomes more realistic and believable, the potential for a tradeoff between hypothetical and strategic bias exists. However, Freeman (1986) argues that surveys provide few incentives to bid in a strategic manner. Furthermore, there is little empirical evidence of strategic bias in contingent value studies (Brookshire *et al.*, 1976; Rowe *et al.*, 1980).

[13] A complete discussion of the potential sources of bias and recommendations for preventative action in CVM surveys can be found in Cummings, Brookshire, and Schulze (1986), Moser and Dunning (1985), and Mitchell and Carson (1989).

6.3 The Roanoke Contingent Valuation Study

Total willingness to pay for a reduction in flood risk was estimated in the Roanoke study area using the CVM method by Thunberg and Shabman (1991). The format and justification for the contingent valuation survey chosen is described in this section. The contingent scenario used in this study is provided and the willingness to pay responses are summarized. In Section 8, these CVM WTP bids will be compared to other willingness to pay estimates obtained using the PDA and hedonic price technique. The WTP bid function is then identified and used to identify which property and nonproperty concerns were most important in explaining WTP.

6.3.1 Survey Administration and Design

In the fall of 1987, a contingent value survey was conducted of owners of flood prone parcels in the Roanoke study area.[14] The total population of 134 landowners within the study area was identified. Each was mailed a contact letter announcing the survey and requesting a personal interview. Interviews were scheduled by telephone and conducted at the landowner's home. Of the 134 landowners, 90 were contacted and agreed to participate in the survey. Of the 90 interviews scheduled, 86 total interviews were conducted. From these conducted interviews, 12 respondents did not fully complete the interview process because of a refusal to answer a question or because they could not understand the WTP question. The 74 useable responses represent 55 percent of the total population of landowners in the study area.

A personal interview was chosen as the survey format over a telephone interview or mail survey for a variety of reasons. Although the personal interview is the most expensive format, it is generally thought to produce the best overall CVM results (Mitchell and Carson 1989; NOAA 1993). The presence of an interviewer increases the amount of thought given to each question, respondent motivation, and response rates. Personal interviews are also better able to handle complex contingent scenarios than mail surveys or telephone interviews. The interviewer is able to respond to questions and present visual aids explaining the problem and project in order to facilitate understanding. Also, a personal interview decreases the amount of protest bids and the total number of questions left unanswered.

In setting up the contingent market, the general characteristics of the project were described to the respondents. The interviewer highlighted some of the damages associated with the 1985 flood and described in general how these damages would be reduced by the construction of the project. Respondents were shown two visual aids illustrating the physical features of the project and a map of the planned location of these features within the survey reach were used.[15]

A description of how the project would reduce the possibility of flooding for the respondent's residents was then provided. The questionnaire used a probability-based definition of

[14] Appendix A contains a copy of the letters and questionnaire of this CVM study.

[15] See Appendix A for the illustrations and charts that were displayed to the respondents.

the commodity to be valued, i.e., flood risk reduction. A probability-based definition of the commodity was selected because it provides a description of the project output without providing cues that might bias responses to willingness to pay questions. For example, if the project were described in terms of the Corps' estimate of the dollar value of avoided property damages, that estimate could have influenced the respondent's bid. Although changes in flood plain designation were available from the Corps, because of a concern that individuals may have difficulty interpreting these probability concepts (Hogarth 1983), a different approach to assessing the individual's view of the project effect was developed.

First, flood probabilities were computed for each parcel under both with and without project conditions where the probability of flooding was defined as the probability of flood waters entering the first floor of the respondents home on at least one occasion in a ten year period. For example, a parcel in the 20 year flood zone would have a 40% chance of being flooded on at least one occasion in ten years. Upon provision of flood control, the same parcel may then lie in the 50 year flood zone and have a 20% chance of being flooded at least once in ten years. The probability of flood water entering the landowner's house on at least one occasion in ten years is equivalent to 1 minus the probability of no flood in the same time period. The binomial distribution (Ott, 1977) was used to compute these probabilities. After the general description of the project, the reduction in the probability of flood water entering the landowner's first floor at least once in a period of ten years was described to the landowner as follows:

> Floods both larger and smaller than the 1985 flood can occur in the future. All these possible floods are considered in planning a project to protect all properties along the river. Therefore, the Corps has calculated the chance of flood waters entering the first floor or basement of your residence both before the project is built and after it is built. If no flood control project is built, there would be a **40%** chance that flood waters would enter the first floor or basement of this residence at least one time in ten years. After the project is built, the chance that flood waters would enter the first floor or basement of your house will be reduced to **20%**.

As each respondent was informed of these flood probabilities a pair of pie charts illustrating both the with and without project chance of flood water entering their home was displayed. Respondents also were offered an opportunity to ask questions about the project. Several follow up questions were asked to insure that the respondent understood the project's effect.

The questionnaire then contained a description of a hypothetical market in which each respondent was asked to make a bid for the project. The landowner was informed that the project cost would be shared between the city and the federal government, but that the actual financial arrangements had yet to be made.[16] Respondents were presented with two possible ways the project could be paid for. First, the respondent was asked to consider the following scenario:

Suppose the cost of the project will be paid by property owners, both commercial

[16] When this study was done, the flood control bond referendum had not been held. Thus, the city had not finalized how it intended to pay for the project.

and residential, as a one time only special assessment as soon as the project is built.

Each respondent was then presented with a card listing dollar amounts from 0 to $5,000 and asked to state how much he would be willing to pay for project construction. The range of payments amounts was selected by determining the maximum and minimum value of avoided property damages as computed by the Corps of Engineers. After an initial bid was provided, the respondent was then asked how much more than this initial bid he would be willing to pay.[17] The initial and incremental bids were then summed and the respondent was asked to confirm whether or not the total bid was a maximum. The lump sum bid was interpreted as the present value of the benefits so it is comparable with the PDA and hedonic price estimates.

In addition to this "lump-sum" payment, the respondents were also asked how much they would be willing to pay for the project construction on a year by year basis. Following the lump-sum payment question, the respondents were told:

> Suppose that the cost of the project will be paid by property owners by a special assessment to be paid once a year for fifteen years after the project is built. You would be liable for the yearly assessment only if you maintain ownership of the property.

Each respondent was then presented with a card listing dollar amounts from $0 to $550 and asked to state the most they would be willing to pay every year for next 15 years to help pay for the project. The single iteration bidding process used in the lump-sum question was repeated for the annual payment question.

The literature regarding the most appropriate WTP question format has been inconclusive. Some studies have shown that the WTP question format results in statistically significant differences in individual WTP responses (Kealy and Turner 1993; Johnson, Brengenzer, and Shelby 1990) while others report that different WTP formats generate similar results (Boyle and Bishop 1988; Reaves 1993). The payment card was chosen over the dichotomous choice and open-ended formats for several reasons. The open-ended question has been criticized as being to difficult for respondents to answer since most people have no experience with valuing a nonmarket good (Reaves 1993). Unlike an opened question, the payment card approach allows to respondent to consider a range of possible WTP bids while the iterative procedure focuses the respondent's attention on the valuation process. The use of the dichotomous choice format raises a number of statistical concerns including the need for large sample sizes to generate robust statistical models (Cameron and Huppert 1991).

Because the objective of contingent value studies is to estimate the benefit of a proposed project or policy, a critical concern in questionnaire design must be any potential bias that might

[17] The use of a payment card eliminated the starting point bias problem associated with iterative bidding format. An initial starting bid provided by the interviewer can influence willingness to pay for flood control if the respondent anchors any subsequent bids on the starting point (Rowe, D'Arge and Brookshire 1980)

affect the final benefit estimates. The survey design and implementation was similar to that of a typical contingent value survey, but the minimization of strategic and hypothetical bias were two particularly important design concerns.

As noted above, strategic bias occurs when a respondent purposefully states a false bid in an attempt to influence the outcome of the study. Flood plain occupants own property and, therefore, could be contacted and asked to pay their stated bid. Also, flood control project costs could be very large, implying that a large payment may be required. These two factors suggest an incentive to bid strategically may exist. There is little empirical evidence, however, that strategic bias is a major problem in contingent value studies. Thus, primary concern for this work was given to constructing a credible contingent market in order to reduce hypothetical bias.

There are two potential sources of hypothetical bias: a lack of experience with flooding consequences or flood control measures, and a failure to believe that the contingent scenario will occur. The former difficulty may also be termed availability bias. Availability bias may arise as a result of the cognitive processes individuals use to make decisions. Tversky and Kahneman (1973) argue that people tend to rely on past experiences in decision making. Thus, the ease with which flood experiences and knowledge of flood control measures can be recalled may affect a survey participant's ability to respond to questions dealing with flood events, flood risks, and willingness to pay. Such biases may result in survey respondents lacking the motivation to consider the survey in a serious manner or they may become confused.

Within the survey area there had been three large flood events within the last 16 years with the most recent event coming in 1985. Furthermore, the project proposal had been reviewed at several public hearings and had received coverage by the local media. Therefore, flood plain landowners were to be familiar with the causes and consequences of flooding and were expected to understand the general effect a flood control project would have on area flooding. To further minimize the possibility of hypothetical bias, actual project details were provided in the course of the survey. Also, although the procedures for paying project costs were uncertain, respondents were informed that payment for the project would be shared between federal and local sources and that beneficiary payment in some form would be required. The intent was to make the contingent market as realistic as possible, reducing hypothetical bias.

6.3.2 Summary of WTP and Protest Bids

Of the 86 CVM interviews conducted, 12 respondents could not provide an answer to the willingness to pay question. These individuals either could not comprehend the willingness to pay question or were unable to attach a monetary figure to the reduction in flood risk. These individuals were identified as "uncertain" bidders.

Over 50 percent of the remaining 74 respondents bid zero for the willingness to pay question. All zero bidders were asked to state a reason for their bid. If they stated that they could not afford more or that the project was not worth anything to them, the bids were distinguished from "protest" bids. Protest bidders were those who bid zero because they objected to being asked their personal willingness to pay. For example, some who protested felt that they had already paid once for the flood problem through damages incurred in the 1985 flood, and so they found it unfair

that they would be asked to pay again (see Appendix A.4). Of the 74 completed interviews 22 individuals made a protest bid.

6.3.3 Explaining Landowner's Willingness to Pay

One of the potential advantages of CVM is that this method is conceptually capable of capturing the nonproperty as well as property benefits associated with a reduction in flood risk. The landowner can be expected to realize benefits from reduced expectations of future expenditures for repair and restoration of real property damaged by flooding. Nonproperty concerns for flood protection are assumed to include: (1) reduced expectations of social and economic disruption of their community caused by a flood event; (2) reduced expectations of post-flood trauma, where trauma is defined as a disordered psychic or behavioral state resulting from the emotional stress or physical injury from an experienced flood event; and (3) reduced pre-flood anxiety, defined as a disordered psychic or behavioral state resulting from a feeling of apprehension or fear over the prospect of flooding, and self-doubt about the capacity to copy with the flood threat. A willingness to pay bid function can statistically distinguish which of these property and nonproperty arguments are most important in explaining the magnitude of WTP bids.

The total willingness to pay for flood protection is hypothesized to be a function of the landowner's subjective valuation of these property and nonproperty concerns and the individual time horizon. The individual's expressed willingness to pay for such a project may further be influenced by the availability of alternative damage mitigation options, e.g. flood insurance, as well as the individuals income position. Therefore, a bid function for a project may be stated in functional notation as in Equation 6.1.

[6.1] $$WTP = f(E\Delta PD, E\Delta LV, E\Delta ANX, E\Delta NBH, FI, INC, TH)$$

where:

WTP = A landowner's expression of willingness to pay for flood control project

$E_{\Delta}PD$ = Individual's expectation for a change in property damages with the project. Property damages are the repair costs expected after a flood event and are related to the structural value of improvements on the flood prone property.

$E_{\Delta}LV$ = Individual's expectation for a change in land values with the project. Because the project yields flood control services over time, the value of those services may be capitalized in land market prices. Empirical studies of real estate markets demonstrate that land values are discounted for flood prone parcels (Donnelly, 1989; Park and Miller, 1982; Thompson and Stoevener, 1983). Presumably, flood hazard reduction benefits would become capitalized into land values increasing the value of a residential flood plain landowner's property. Thus, expectations for increases in property values increase willingness to pay for flood protection services.

$E_{\Delta}ANX$ = Individual's expectation for a reduction in anxiety with the project. Reduced

pre-flood anxiety is defined as a disordered psychic or behavioral state resulting from a feeling of apprehension or fear over the prospect of flooding and self-doubt about the capacity to cope with the flood threat.

$E_{\Delta}NBH$ = Individual's expectation for a reduction in social and economic neighborhood disruption.

FI = Whether the individual owns flood insurance.

INC = Income of the individual.

TH = Time horizon of the individual.

Ownership of flood insurance is a substitute for a project and would be expected to reduce willingness to pay. All other variables in Equation 6.1 should be positively related to willingness to pay. $E_{\Delta}PD$ and $E_{\Delta}LV$ are the individuals' expectations for positive property value effects of the project. $E_{\Delta}ANX$ and $E_{\Delta}NBH$ are non-property services expected from the project. This bid function is expected to show the relative contribution of property and nonproperty flood risk reduction arguments to willingness to pay.

After describing how the project changed the probability of flooding for their residence, a series of survey questions were posed to the respondents which were designed to obtain the necessary data to estimate the general WTP bid function, as expressed by Equation 6.1. Respondents were asked whether they felt the project would: (0) increase, (1) not change, (2) slightly reduce, (3) moderately reduce, (4) greatly reduce, or (5) eliminate the chance of flooding of the landowner's property. An index was then created using the indicated numbers to rank the respondent's judgement about the project's effect on the probability of flooding at their home. This variable was labeled *DPROB*.

Nonproperty effects of the project include anxiety reduction and reduction in neighborhood disruption. The anxiety variable was measured as an index of flood related anxiety using scaling procedures similar to those used by the Corps for its trauma surveys (Allee *et. al.* 1980; Blocker and Rochford 1986). Specifically, each respondent was asked to place on a four point Likert scale, the degree to which he or she felt helpless, afraid, depressed, and upset when flood warnings are issued. The Likert scale offers the advantage of allowing the respondent to express a degree of emotion rather than just a yes or no response (Blocker and Rochford;1986). Warheit (1979), Hansson *et al.* (1982a), and Hansson *et al.* (1982b) provide examples of the use of Likert scaling techniques for measuring stress related to natural hazards. An anxiety index was constructed by summing the scale value for each of the four different types of emotions to form a single measure of flood related anxiety. This variable was labeled *ANX*.

The effect of the project on the neighborhood was described by explaining how the project would have reduced the damages to the entire city in the most recent flood had the project been in place. Specifically, the respondent was read the following:

The flood of November 1985 was one of the largest floods recorded for the Roanoke

River. That flood disrupted the lives of thousands of people in the Roanoke valley. Over 5,000 houses were damaged. Many businesses were damaged, as well being forced to close; some never reopened. Several bridges and roads were closed for days or weeks following the flood, making travel in and around the area difficult and causing many people to lose time at work. If a similar flood were to occur again, on average, flood damages to Roanoke residents and businesses would be reduced by nearly one half, and critical facilities such as the Roanoke Memorial Hospital would be completely protected. In this area, from the hospital to the 9th street bridge, if a flood similar to the 1985 flood were to occur after the project is built, flood damages would be expected to be three quarters lower than they would be if no project is built.

Each respondent was then asked whether he or she felt the project would have: (0) a negative effect, (1) no effect, (2) a small effect, (3) a moderate effect, or (4) a large effect on the welfare of their community. An index of the participant's subjective assessment of the project's importance to the neighborhood was then created using the indicated numbers to rank the respondent's judgement about the project's effect on their community. This variable was labeled *NBH.*

Property effects of the project will depend upon the structural value of the home on the land parcel and the expectations individuals have for land prices after the project. Data for the estimated structural value of the landowner's home in $1,000s was obtained from the Wilmington District Office, US Army Corps of Engineers. This variable was labeled *SV.*

After the project description was completed each respondent was asked how he or she felt the project might affect property values. Specifically, each participant was asked whether he or she felt that property values would: (0) go down, (1) not change, (2) go up slightly, (3) go up moderately, or (4) go up a lot after project completion. If the respondent did not know how the flood control project would affect property values it was determined that expectations for property value changes would not influence WTP for flood control. Therefore, a value of zero was assigned in these instances. An index was created using the indicated numbers to rank the respondent's judgements about the project's effect on property values. This variable was labeled $E_{\Delta}LV$.

From Equation 6.1, other factors expected to affect willingness to pay included ownership of flood insurance *(FI)*, household income *(INC)*, and the individuals time horizon *(TH)*. Flood insurance was measured with a dummy variable having a value of 1 if the respondent indicated that he or she had purchased flood insurance. A value of 0 was assigned otherwise. Income was measured as household income from all sources. Eight income categories at $10,000 intervals were used and respondents were asked to report their household income in one of the eight categories. The respondent's time horizon for flood plain property ownership was measured with a dummy variable having a value of 1 if the landowner had immediate plans to sell the property. Respondents that did not intend to sell the home in the near future were assigned a value of 0.

With these measurements from the survey, a statistical model, derived from Equation 6.1, was developed. The expected changes in property damages $(E_{\Delta}PD)$ and anxiety relief $(E_{\Delta}ANX)$ were represented as the product of the landowner's subjective judgement of the change in the probability of a flood *(DPROB)* with structural value *(SV)* and flood related anxiety measures

(ANX) respectively. If a landowner perceives no change in flood probability then expected damage reduction and anxiety relief services of the project will be zero. Other variables in the statistical model were direct measures from the survey of variables from Equation 6.1. Finally, to allow for the likelihood of diminishing marginal utility, the model was specified in logarithmic form. Thus, Equation 6.2 presents the statistical model to be estimated.

$$[6.2] \quad \begin{aligned} \ln WTP &= B_0 + B_1 \ln(E\Delta ANX) + B_2 \ln(E\Delta PD) + B_3 \ln(E\Delta NBH) \\ &+ B_4 \ln(E\Delta LV) + B_5 FI + B_6 TH + B_7 \ln(INC) + \varepsilon \end{aligned}$$

6.3.4 Model Results

An initial problem in interpretation of the results is that of the 74 completed interviews 22 made a zero bid for reasons other than an inability to pay or that the project would provide no benefit. These zero bids, termed protest bids have been a source of discussion in the contingent valuation literature (Stoll, *et al.* 1983; Cummings, *et al.* 1986; Mitchell and Carson 1989). One argument is to drop the protest bids from the empirical analysis (Moser and Dunning 1985) but Edwards and Anderson (1987) argue that omission of protest bids constitutes a sample selection rule and introduces the possibility of sample selection bias. To test for and correct for any sample selection bias that might be introduced as a consequence of omitting the protest bids from the sample Heckman's two-stage estimation procedure was used.

Heckman (1976) proposes a simple procedure in which a probit model is specified for the full sample. For our purposes the dependent variable in the probit model takes on a value of 1 if the respondent gave a protest bid and zero otherwise. The probit model is then used to estimate λi, the inverses of Mill's ratio (see Section 2 in Heckman for further details), for each observation. The Mill's ratio provides a measure of the representativeness of a given observation of the entire population. Thus, where sample selection is not a problem, λi approaches zero. The second stage in the estimation uses OLS with λi included as an explanatory variable in the bid function. If the null hypothesis, Ho: $\lambda i = 0$ cannot be rejected then omission of protest bids does not introduce sample selection bias.

Sample selection bias was rejected using Heckman's two-stage estimation procedure, therefore, Table 6.1 reports the coefficient estimates with the observations having protest bids eliminated from the analysis. The results in Table 6.1 report relationships between property and nonproperty flood control concerns and willingness to pay for flood control at the .10 level of significance. Of the variables hypothesized to influence willingness to pay, only *TH* is not statistically significant. All other variables are statistically significant and are of the anticipated sign. Also, there was no evidence of collinearity. Flood insurance appears as a substitute for structural flood control. Evaluated at sample means and setting all dummy variables to zero the predicted value of willingness to pay for a landowner that did not purchase flood insurance would be $188.63. The predicted willingness to pay for an individual that did purchase flood insurance is $36.81.

These findings indicate that nonproperty flood control services represent an important component of flood control benefits. In fact, within this study the relative importance of property

protection *($E_{\Delta}PD$ and $E_{\Delta}LV$)* to nonproperty arguments *($E_{\Delta}ANX$ and $E_{\Delta}NBH$)* can be examined. The coefficient estimates for the logged variables are equivalent to point elasticities for the bid function. For example, a one percent increase in the measure of reduced neighborhood disruption *($E_{\Delta}NBH$)* results in a 2.358 percent increase in willingness to pay for flood control. The magnitude of the elasticities can be ranked in the following order: neighborhood affects, expected protection of home *(DPROB * SV)*, expected property value increase, and expected reduction in anxiety.

In this study, willingness to pay for the flood control project under consideration was most sensitive to nonproperty neighborhood concerns. Also, while anxiety was a significant variable, real property effects of personal property protection and expectations for property value increases had greater elasticities than reduced anxiety levels.

Table 6.1: Bid Function Coefficient Estimates.

Variable	Parameter Estimate	Standard Error	t-statistic
INTERCEP	-8.523	3.229	-2.640 *
$E_{\Delta}ANX$	0.605	0.242	2.503 *
$E_{\Delta}PD$	1.427	0.606	2.355 *
$E_{\Delta}NBH$	2.358	1.271	1.856 *
$E_{\Delta}LV$	0.801	0.441	1.816 *
FI	-1.634	0.690	-2.367 *
TH	0.672	0.720	0.940
INC	1.698	0.537	3.163 *

N = 52

F Value = 6.002

Adjusted R^2 = 0.407

* Significant at the .10 level

SECTION 7

VOTING BEHAVIOR IN THE ROANOKE FLOOD CONTROL REFERENDUM

The purpose of this report is to compare the flood hazard reduction benefit estimates for three methods: property damages avoided (PDA), hedonic price (land price analysis), and contingent valuation method (CVM). Yet, none of these three methods are based on actual choices concerning flood hazard reduction. The Roanoke bond referendum, which was held to help finance the flood control project, reveals choices about flood risk reduction and the flood control project directly through voting behavior.

In April 1989, a special referendum was called asking voters to approve a $7.5 million bond issue to finance the Roanoke flood control project. This was the first single issue bond referendum of its type in city history. The city-wide utility tax would be raised from 10 to 12 percent to repay the bond. The city estimated that the increase in taxes would be approximately $2.00 per month for the average household's utility bill. Without voter approval of the bond issue, the channelization plan could not be built. Furthermore, since alternative flood reduction proposals were considered politically infeasible, rejection of the bond issue implied that the city would be without any flood protection measures for years to come. The bond issue passed with over 56 percent support (4,271 to 3,273), with 19.6 percent of the registered city voters casting ballots.

The bond referendum, which called specifically for voter approval of this particular bond issue, was not held in conjunction with any local, state or national election. Also, there had been no highly controversial taxation or spending debates in the City of Roanoke in recent years. Thus, voter turnout can be directly attributed to the flood control issue. Also, because the bond issue was to be only for the flood control project, individual voter's benefits and tax costs were clear and tied directly to the flood control project.

The Roanoke bond referendum offers a rare opportunity to examine how citizens actually evaluated the benefits and costs of this flood control investment. A telephone survey was administered city-wide in order to identify what factors were important in explaining citizen's voting choices. Unlike the PDA, hedonic price, and CVM studies, this study of voting behavior was not confined to just those living in case study area, but included all Roanoke citizens. Particular emphasis was placed on determining the extent to which those living and working outside the flood plain were willing to support, and thus pay for, the project.[18]

7.1 Possible Voter Motivations in the Roanoke Bond Referendum

Voting behavior examined in the Roanoke referendum can be described as three separate choices: the decision to register to vote the decision on whether to participate in a given election, and the decision of how to vote (Southwell 1987). The decision to register was not considered in this study since the registration decision was unlikely to be affected by this limited issue election.

[18] Unlike the previous three sections, this section does not attempt to quantify the benefits of flood control.

Although the factors which explain the decisions of whether and how to vote is the subject of continuous debate, voting behavior is seen partly as a symbolic act and partly as an instrumental act. As a symbolic act, the benefits of voting are realized without regard to the outcome of the election. Here voting is motivated by civic pride or a sense of duty for a person living in a democracy. However, people vote in favor or opposition to a candidate or proposal because they believe their vote will be instrumental in influencing the election's outcome. Two possible instrumental motivations have been identified for voters. First, voters can cast a vote to advance or protect personal goals, representing property and personal arguments. Second, they can cast a vote to advance or protect the welfare of the community in which they live, representing neighborhood and civic arguments. This second possibility recognizes that many people identify closely with the community in which they live. That is, they are proud to be from the community and this is an important part of their self image. The focus of this Section is on which of these two instrumental motives were most important to Roanoke's registered voters' decision to participate in the flood control referendum.

Possible personal and community benefits and costs associated with the flood control referendum are listed in Table 7.1. For those who live, work, or own property in the flood plain there appears to be a large personal incentive to turn out and vote in the referendum. For the flood plain residents, the extensive damages from the 1985 flood should create an expectation of substantial benefits from voting, benefits which are larger than the tax increase. On the other hand, individuals outside the flood plain might turn out to vote against the project to avoid the tax increase for a project which provides them with no personal benefits. However, the two percentage point tax increase in the monthly utility bill for the duration of the bond repayment period suggests only limited financial benefits from voting, in terms of taxes avoided, for those living outside the flood plain. Therefore, if only personal motivation mattered, voter turnout will be expected to be higher for those people affected by flooding than for the community at large.

Table 7.1: Possible Instrumental Motivations of Voters in the Roanoke Flood Control Project Referendum.

Personal Benefits:
- protect home
- protect work place
- protect property

Community Benefits:
- Community economic development
- Help others who suffer from flooding
- Environmental change (positive or negative)

Personal Costs:
- Tax Increase

People may choose to vote out of concern for the community, recognizing that their tax costs will rise. As shown in the contingent valuation study, many flood prone residents valued the

flood control project for the services it would provide to their neighborhood (Thunberg and Shabman 1991). For those living and working outside the flood plain, the possible civic benefits of the project include maintaining the economic base of the city and helping other citizens who suffer from flooding. However, a vocal opposition to the Roanoke project did come from several local environmental groups which felt the channelization plan would destroy the scenery and environment along the Roanoke River. This perception of a community environmental cost may stimulate citizens to vote.

Once in the polling booth, the arguments made in Table 7.1 apply to the decision about whether to support or oppose the bond issue. People directly affected by flooding either at their residence or place of work would be expected to vote for the project due to the large potential excess of personal benefits over tax costs if the referendum passed. In the Roanoke referendum, however, the number of people affected by flooding is a small percentage of the city population. The key to the election outcome rests with those people living and working outside the flood plain; that is, how many will vote and how they will vote as they balance flood protection benefits for the community against their personal tax costs.

7.2 The Voter Survey

A telephone survey was administered to registered voters in Roanoke one week following the vote on the bond referendum.[19] The survey was designed prior to the vote itself and was intended to determine which motivations from Table 7.1 were important in the referendum result, whatever the outcome of the election. To assure a random sample of registered voters, telephone numbers were selected via a random number generating process for telephone exchanges within the city, thus including all residents with a telephone including listed and unlisted telephone numbers. Only those who were registered to vote and were aware of the election were asked to respond to the survey questions. The person who answered the phone, if registered to vote, was asked to respond to the survey. If they were not registered, another registered member of the household was interviewed. The survey was designed to take less than five minutes to complete to ensure that the respondents would willingly participate and to fit within budget limitations of the study. All respondents were assured strict confidentiality.

A total of 492 surveys were completed and suitable for analysis. Twenty two percent of the sample of registered voters voted in the election, compared to the 19.6 percent voter turn-out for the actual election. Of those in the sample who voted in the election, 50 percent voted for the project. With 56 percent of the voters supporting the project in the April election, the survey sample slightly underestimated voter support for the project. However, the 56 percent voting "yes" fell within the sample 90 percent confidence interval of 41.1 percent to 57.8 percent.

7.3 Survey Results: The Decision to Vote

First, the sample of registered voters was divided into those who went to the polls and those who stayed home. Responses to questions concerning voter motivations were then compared

[19] Appendix B contains a copy of the telephone survey.

between the group of voters and nonvoters. Since all questions were categorical, Chi-squared analysis was used to test the hypothesis that the true response probabilities for each question was the same between the voters and nonvoters. In this manner it was possible to compare voters and non-voters motivations and isolate those cases where there was a statistically significant between group difference.[20]

The personal benefit variables, which were hypothesized to be a critical motivating element in the decision to vote, did not distinguish voters from non-voters. Voters were no more likely than nonvoters to feel that the project would effectively protect their work place against future flooding as summarized by responses to question a) in Table 7.2. Also, voters were less likely than nonvoters to feel that the project would effectively protect their current home from future flooding as responses to question b) in Table 7.2 indicates.

Table 7.2: Personal Benefits and the Decision to Vote.

a) Will the proposed flood control project effectively protect your current place of work from future flooding?

	NONVOTER	VOTER
YES	35%	35%
NO	56%	59%
UNCERTAIN	9%	6%

b) Will the proposed flood control project effectively protect your present home from future flooding?*

	NONVOTER	VOTER
YES	26%	16%
NO	65%	76%
UNCERTAIN	9%	7%

* Statistically significant difference at the .05 significance level

Avoidance of the tax increase represented a possible reduction on a voter's wealth and represented the other personal motivation to vote. However, many of the voters who made the decision to vote were unaware or unconcerned with the individual tax costs their vote would affect. Voters were more aware of the existence of the proposed tax increase than the nonvoters, question a) in Table 7.3. Seventy-eight percent of the voters knew their taxes would increase if the bond issue passed, while only 61 percent of the nonvoters realized their taxes would increase. Therefore, a significant percentage of all registered voters were aware of the potential for a tax increase. Those persons who said they were aware of the possible tax increase were asked to estimate how much

[20] In addition to Chi-squared analysis, multivariate logit regressions were used to model both the decision to vote and the decision of how to vote (Shabman and Stephenson 1994). The results from these regressions confirmed the chi-squared analysis.

their taxes would rise. Of those who were aware of the tax increase, voters were more likely than non-voters to have an estimate of the amount of tax increase. What is particularly striking, as indicated by responses to question b) in Table 7.3, is that even among those who knew taxes would be increased, large proportions in both the voter and non-voter group were unable to state how much their tax would increase.

Table 7.3: Personal Costs and the Decision to Vote.

a) Before the referendum did you believe that you would have to pay higher utility taxes if the bond issue passed?*

	NONVOTER	VOTER
YES	61%	78%
NO	28%	7%
UNCERTAIN	11%	15%

b) How much MORE did you expect you would pay in utility taxes per month if the bond issue passed? (Only includes those who were aware of the tax increase.)*

	NONVOTER	VOTER
LESS THAN $2	21%	39%
$2.01 - $5	15%	10%
$5.01 - $10	3%	2%
MORE THAN $10	4%	6%
UNCERTAIN	57%	43%

* Statistically significant difference at the .05 significance level.

The results presented in Tables 7.2 and 7.3 suggest that personal motivations did not provide an adequate basis for separating voters from non-voters in the Roanoke referendum. Respondents also were asked two questions about the effect of flooding on economic development and the environmental impact of the project to determine whether community motivations influenced the decision to vote. Only the responses to environmental questions showed a statistically significant difference between the voters and nonvoters, with voters more likely to feel the project would harm the environment. The environmental opposition was not particularly large, however, with only 36 percent of the voters and 20 percent of the nonvoters feeling the project would harm the environment. A majority of both nonvoters and voters felt flooding hurt economic development in the Roanoke Valley, although there was no significant difference between the two groups in their view. In general, neither community nor personal instrumental motivations proved particularly useful in differentiating voters and nonvoters.

7.4 Survey Results: The Decision of How to Vote

Among voters, what factors were important in the decision about how to vote? For the 97 people who went to the polls and revealed how the voted, the sample was broken down into those who voted for the project and those who voted against the project. Chi-squared analysis was used

to test for differences between group differences in voter motivations.

First, consider the possible reasons why a voter would cast a "no" vote. Project opposition may have been based on the increased tax burden. Although a large majority of both supporters and opponents of the referendum knew of the tax increase, opponents were more knowledgeable about the tax increase than supporters. Nearly three-quarters of the project supporters believed they would have to pay higher utility taxes if the project passed, compared to about 88 percent of the opponents as expressed by the results summarized in Table 7.4. There was a statistically significant difference in knowledge of the tax increase between opponents and supporters. However, since the vast majority of both groups knew of the tax increase, it is not possible to conclude that the tax increase was a primary factor motivating how people voted. This argument is further developed below when Tables 7.9 and 7.10 are discussed.

Table 7.4: Personal Costs and How to Vote.

Before the referendum did you believe that you would have to pay higher utility taxes if the bond issue passed?*

	OPPONENT	SUPPORTER
YES	88%	73%
NO	6%	6%
UNCERTAIN	6%	21%

* Statistically significant difference at the .10 significance level.

The voter also could have opposed the bond issue out of concern for the environment. Well over half of the project opponents felt the project would harm the environment, with less than a quarter of the supporters feeling the project was environmentally harmful. Indeed, supporters suggested the environment would be helped by the project see Table 7.5). This perception of a community cost seems more important in opposition to the project than the financial cost.

Table 7.5: Community Benefits and How to Vote (A).

How do you feel the flood control project will affect the environment along the Roanoke River?*

	OPPONENTS	SUPPORTERS
HARM ENVIRONMENT	55%	23%
IMPROVE ENVIRONMENT	14%	40%
NO AFFECT	16%	25%
DO NOT KNOW	14%	12%

* Statistically significant difference at the .05 significance level.

Now consider the reasons why the voter would have supported the project. The personal benefit goals, which played a small role in differentiating voters and non-voters, proved to be an important factor in separating supporters from opponents. Project supporters were more likely than opponents to feel the project would protect their current home and work place from future flooding

as expressed by results in Table 7.6. In fact, not a single person in the sample who voted against the referendum felt the project would protect their home. People living in the flood plain, and who went to the polls, voted consistent with their personal interests.

Table 7.6: Personal Benefits and How to Vote.

a) Will the proposed flood control project effectively protect your present home from future flooding?*

	OPPONENT	SUPPORTER
YES	0%	33%
NO	96%	56%
UNCERTAIN	4%	11%

b) Will the proposed flood control project effectively protect your current place of work from future flooding? *

	OPPONENT	SUPPORTER
YES	6%	37%
NO	92%	56%
UNCERTAIN	2%	6%

* Statistically significant difference at the .05 significance level.

Although nearly everyone who felt their home or work place would gain some protection from the construction of the project voted for the project, the total number of people in the sample who felt they gained some protection was small. Table 7.7 indicates that only slightly more than 30 percent of the voters expected that they would gain protection. Yet the project passed with 56 percent of the vote (50 percent in the sample). Therefore, while personal benefits were important, it does not explain the motivations of a substantial percentage of the project supporters.

Table 7.7: Level of Perceived Flood Protection (Voters).

	All Voters
Project will protect my home:	17%
Project will protect my work place:	22%
Either house or work place will gain protection:***	30%

*** This measure was created by combining the questions from Table 7 to eliminate double counting those for whom both home and place of work would be protected.

It was necessary for voters to consider the interest of the community for the project to pass. Statistical differences were found between supporters and opponents over the impact of flooding on economic development. Table 7.8 indicates that three quarters of the supporters felt the flooding hurt economic development, compared to only 37 percent of the opponents. An open-ended question on the survey best demonstrates the strength of community spirit motivations in the election. Respondents were asked what was the single most important reason for supporting the

project. These responses were classified into the groups shown in Table 7.9. By far the most frequent reason given for supporting the project was to help other people suffering from flooding (40 percent), followed by protection of home and work place (25 percent) and to boost the local economy (17 percent). This clearly highlights that the majority of the people who voted, voted for the project out of concern for others or the community. In fact, the bond issue would have been overwhelmingly rejected if people considered only personal benefits in making their voting decision.

Table 7.8: Community Benefits and How to Vote (B).

Do you feel that the threat of flooding hurts the future development of the Roanoke Community or not?*

	OPPONENT	SUPPORTER
YES, HURTS DEVELOPMENT	37%	75%
DOES NOT HURT DEVELOPMENT	55%	21%
NOT SURE	8%	4%

* Statistically significant difference at the .05 significance level.

Table 7.9: Most Important Reason for Voting for the Project (Voters).

Improve environment:	8%
Protect home or work place:	25%
Boost city economy:	17%
Help people in the city who suffer from flooding:	40%
Provide city with protective measures:	8%
Others reasons:	2%

Opponents of the project were also asked what was the single most important reason they voted against the project. These responses are summarized in Table 7.10. Of those who opposed the project only 20 percent based their vote on the tax increase. Although there were some differences between the opponents' and supporters' knowledge of the tax increase, the issue of taxes did not seem to be the dominant reason for people to oppose the project. Those who opposed the project were more likely to state that the project was not best for the community, again suggesting that many voters looked beyond their personal benefits when entering the polling booth.

Table 7.10: Most Important Reason for Voting Against the Project (Voters).

Harm environment:	10%
Would not be an effective flood control measure:	12%
Oppose higher taxes:	20%
Not best solution:	31%
Unnecessary expense:	6%
Others:	20%

7.5 Survey Results: Project Support Among Non-Voters

The low voter turnout requires caution in drawing conclusions about community-wide benefits from the behavior of only those who chose to vote. What if the voter turnout had been much higher, approaching the 60 percent level the city often has in national and statewide elections? In the survey, people who did not vote were asked how they would have voted if they had gone to the polls and why they supported or opposed the project.

Among non-voters referendum supporters outnumbered opponents 71 percent to 29 percent. In response to an open-ended question on why they did not vote, only 21 percent of the non-voters stated that they didn't care about the project or they didn't have enough information. Seventy-one percent offered inconvenience or not remembering the election as a reason for not voting. Based upon these results, it appears that if the turnout had been higher the election result would not have been different since reasons for not voting seem unrelated to views on the merits of the flood control referendum. Clearly, however, the intensity of feeling about the project was low for nearly three-quarters of the non-voters, otherwise they would have remembered the election or not found it inconvenient to vote.

While failing to muster enough energy to vote, the non-voters were supportive of the project. Like those who voted, the non-voters' support was based on community concerns rather than individual ones. In response to an open-ended question, the two most important reasons given by the nonvoters for supporting the project were to help others who suffer from flooding (49 percent) followed by improving the environment (18 percent).

7.6 Discussion

The voting behavior and motivations among voters and non-voters discovered by the survey suggests that willingness to pay for flood control extends beyond individual landowners in the flood plain. For the Roanoke referendum to pass, people had to vote a tax on themselves even though there was no direct benefit to their residence or place of work. Also, while the voter turnout was low, results of a survey of non-voters makes it clear that the election results, and reasons for those results, would not have been changed if voter turnout had been higher. Thus, considering flood control benefits entirely in terms of willingness to pay for benefiting landowners may likely understate the community's willingness to pay for the project. The implications these results have in relation to the PDA, CVM, and hedonic price method will be described in Section 9 of this report.[21]

[21] The telephone voter survey data are not used directly to compare voter behavior with the results from the PDA, CVM, and hedonic price methods in Section 8 of this report. Voter information for landowners in the Roanoke case study area was obtained through the City of Roanoke's voter registration office. Thus, voter behavior used for direct comparison purposes in Section 7 included whether or not the landowner was registered to vote, and whether or not this individual voted in the referendum, but did not include how the individual voted.

SECTION 8
BENEFIT ESTIMATE COMPARISON FOR IDENTICAL PROPERTIES

The previous Sections discussed three basic benefit estimation techniques used to monetize the value of flood hazard reduction in the City of Roanoke. Each method was then used to estimate residential flood hazard reduction benefits for a proposed flood control project. While each technique is designed to provide an empirical estimate of the same conceptual standard, willingness to pay, each technique: has different abilities to measure property and nonproperty benefits, has different assumptions about personal risk attitudes and discount rates, makes varying assumptions about the information used to evaluate the consequences and probability of flooding, and lastly, utilizes different data sources and benefit quantification procedures. The interest in this Section is to compare the results of the three techniques to determine the consequences of these differences on final benefit estimates.

8.1 Summary of the Three Methods and Roanoke Case Studies

In Section 2, a conceptual framework which outlined the different types and sources of flood risk reduction benefits was described. Besides the benefits to property, flood risk reduction may also contain significant nonproperty benefits. For those residing in the flood plain, the reduction in the threat of flooding may reduce flood-related anxiety and trauma, i.e., personal nonproperty benefit. Besides these personal property and nonproperty benefits, a flood event can also cause the general social and economic disruption of the residents' neighborhood. Individuals may incorporate the effects on their neighborhood into their subjective valuation of increased flood protection services. These influences were labeled "neighborhood nonproperty benefits." Also, those residing outside the flood plain may value flood protection out of a sense of community or moral responsibility. These nonproperty benefits were termed the "civic benefits" of flood risk reduction. Section 7 provides evidence that these benefits do indeed exist.

Each of the three benefit estimation techniques, PDA, Hedonic Price Analysis, and CVM have different capacities to capture the property and nonproperty components of flood hazard reduction benefits. Property Damages Avoided is the narrowest of the three techniques and assumes that willingness to pay for flood protection is based only on the reduced damages to property. Unlike PDA, the CVM and Hedonic Price techniques are conceptually capable of reflecting the nonproperty benefits of flood control for those directly affected by flooding.

To the extent that personal and neighborhood nonproperty benefits enter into land market traders' subjective property evaluations, Hedonic Price Analysis will reflect both property and nonproperty benefits for landowners in the flood plain. Yet, the statistical procedure used to generate benefit estimates with this technique does not distinguish between the contributions property and nonproperty benefits individually make to total estimated benefits. Second, Hedonic Price Analysis is not capable of capturing the civic benefits of flood control since a change in the probability of flooding stemming from the construction of a flood control project is unlikely to have any impact on the value of property outside the flood plain.

The CVM is conceptually able to reflect the entire range of flood control benefits. Total willingness to pay for the reduced risk of flooding is measured directly by respondents' answers to

questionnaires. Furthermore, statistical analysis of the willingness to pay bids in the Roanoke study area was able to identify the relative importance of property, personal nonproperty, and neighborhood nonproperty concerns in the individual's hypothetical willingness to pay decision. Concern for the adverse consequences of flooding on the individual's neighborhood was found to be the most important factor in explaining flood reduction benefits. The reduction in property damages was also a significant factor in explaining willingness to pay for flood control. Although the Roanoke CVM study did not attempt to do so, the CVM is also capable of generating estimates of the civic benefits of flood control. Evidence from the voting patterns in the Roanoke flood control bond referendum revealed that many citizens living and working outside the flood plain were willing to pay additional taxes in order to build a flood control project. A contingent valuation survey of nonflood prone residents could have been conducted to reflect these benefits.

Thus, strong evidence from the contingent valuation and voting studies supports the conclusion that nonproperty benefits, from both inside and outside the flood plain, are a significant component of total flood reduction benefits. The PDA, therefore, will not represent society's total willingness to pay for flood protection. If the measurement of flood protection benefits is limited to flood plain residents, the Hedonic Price method is conceptually able to reflect both property and nonproperty concerns. To the extent that individuals outside the flood plain value flood protection services, the Hedonic Price method will also underestimate the community's total willingness to pay.

The economic model of rational choice outlined in Section 2 describes the individual choice to pay for flood risk reduction through the process of maximizing discounted expected utility. Important components in the rational choice process include the individual's knowledge of flood risks, personal discount rate, and risk preferences. All three of the methods examined here are ultimately grounded in this conception of choice. The Contingent Valuation and Hedonic methods are based on flood plain residents and land market traders assessment of the probability of flooding. The PDA benefit estimates are explicitly based on statistical "objective" notions of probability. Results from the Hedonic Price equation revealed that land traders' assessment of flood risk was different from the project planner's. For instance, land trader's placed a significant premium on the relative flood "freeness" of a property after the 1985 flood, but prior to 1985 land buyers appeared indifferent to the property's level of flood risk. Although the probabilities of flooding had not changed, the results of the hedonic price analysis clearly showed that landowner's perception of the flood risk had changed after the 1985 flood. Thus willingness to pay as captured in the Hedonic Price equation suggests landowners and water resource planners have different understandings about the threat of flooding. The CVM can partially overcome this information problem by providing survey respondents with specific information about the probability of flood risk.

In addition to assumptions about the respondents understanding of the consequences and probability of a flood event, PDA also assumes that people are risk neutral and hold the same discount rate as the project planner. If either assumption is violated, PDA will deviate from the willingness to pay conceptual standard. Since the Hedonic Price and CVM methods obtain flood risk reduction benefit estimates indirectly or directly from the people affected by flooding, these methods do not require imposition of the assumption that the planning model and flood plain occupants have similar risk attitudes and discount rates.

Finally, Sections 4 through 6 described the assumptions and general limitations of each benefit estimation technique to reflect total willingness to pay. Each of these limitations hold important implications for the ability of each method to estimate measures of willingness to pay. As discussed in Section 4, the PDA method is based on several unrealistic assumptions which were necessary for the PDA benefit estimates to conceptually correspond with the total willingness pay for a reduction in flood hazard. In many cases, these assumptions will be violated, e.g., the assumption of no nonproperty benefits. The Hedonic Price method is sensitive to the choice of an appropriate statistical model and can be used only for marginal changes in flood risk. For a nonmarginal change in flood risk associated with a flood control project, Hedonic Price Analysis will over represent total willingness to pay and adjustments must be made. Since the Roanoke flood control project is expected to result in significant changes in the probability of flooding for those most susceptible to flooding, the potential over representation of benefits is greatest for the most flood prone the properties. Finally, the CVM is subject to a number of survey and motivational biases. It is often impossible to detect these biases or determine how a bias once detected influences the willingness to pay bids.

8.2 Comparison Data

It is not clear how these differences between the different benefit estimation techniques will cause final benefit estimates to differ. In order to make comparisons, benefit estimates should be generated for an *identical* set of land parcels and their respective owners. Thus, a given parcel in the Roanoke case study area was included in this comparison if there was a PDA and Hedonic Price estimate for a given parcel and a CVM bid and evidence of voting behavior for the owner of that parcel.

The comparisons analyzed here are based on 73 observations. As part of its flood control project feasibility study, the Corps calculated the value of property damages avoided for each of the 141 residential properties in the study area. As explained in the Section 6 of this report, from a total population of 134 landowners, a total of 86 CVM interviews were arranged and conducted.[22] Unless otherwise noted, all respondents who protested or who could not answer the willingness to pay question were included in the comparative analysis in this Section. All CVM respondents were included in this analysis since the purpose here is to compare the individual benefit estimates of each method.[23]

The estimated Hedonic Price equation reported in Section 5 was then used to estimate the flood reduction benefits for each of these 86 parcels. Using Corps data, the reduction in flood risk provided by the project was calculated and presented in Table 5.2. Along with the house and lot characteristics for each property, the calculated change in flood risk was substituted into the

[22] The difference between the 141 properties and 134 landowners is explained by the fact that 7 landowners owned multiple properties in the study area.

[23] In the Section 6 of this report, protest and uncertain bidders were dropped from the sample since the primary purpose there was to explain the WTP decision for those respondents expressing a bid.

Hedonic Price equation which generated an estimate of the change in property value due to the reduction in flood hazard. The difference in the estimated property values with and without the project was the Hedonic Price benefit estimate of the value of reduced flood risk.

The voting records for the all 86 landowners were then checked at the City of Roanoke's voter registration office. The voting records showed whether the landowner was registered to vote and whether he voted in the Roanoke flood control referendum.[24] Through examination of voter registration files, the voting records of 74 landowners were identified. The remaining 13 landowners did not reside within the city at the time of the referendum and, therefore, were ineligible to vote. These 73 observations provided the basis for comparison.[25]

Benefit estimates were for the reduction in flood risk for residential properties that would be provided by the construction of the U.S. Army Corps of Engineers flood control channelization project in Roanoke. Since benefit estimates are for flood plain residents only, civic benefits from the project were not examined. Total benefit estimates derived for each property or landowner under the PDA, hedonic price, and CVM methods are interpreted as the discounted expected flow of future flood risk reduction benefits.

To date there has not been any research which compares the results of these three different techniques. Other comparative studies of nonmarket benefit estimation techniques have compared the travel cost and contingent valuation methods (Thayer 1981; Steller, Stoll, Chavas 1985; Smith, Desvousges, and Fisher 1986; Loomis, Creel, and Park 1991) and the CVM and hedonic price methods (Brookshire, Thayer, Schulze and d'Arge 1982; and Blomquist 1988). Bishop and Heberlein (1986) compared the results from contingent valuation study and travel cost studies against those generated in a simulated market. The findings of these comparative studies have been mixed. Some researchers have found that different nonmarket techniques generated similar results (Thayer 1981; Steller, Stoll, Chavas 1985). In comparing hedonic and CVM estimates for the value of a scenic view, Blomquist (1988) found CVM estimates were not significantly greater than hedonic estimates. Other researchers have found less encouraging results. Brookshire *et. al.* (1982) found hedonic price benefit estimates were double or triple CVM estimates, but concluded these differences could be explained by the limitations of the hedonic price method. Smith, Desvousges, and Fisher (1986) reported significant differences in benefit estimates between two travel cost and two CVM models. Bishop and Heberlein (1979, 1986) and also found significant differences between the CVM and a simulated market approach.

Besides comparing the PDA, contingent valuation and hedonic price methods for the first time, this research expands on previous comparison work in two other ways. With the exception of Smith *et. al.* (1986) and Blomquist (1988), comparisons have not been made with an identical set of

[24] Since the Roanoke voter telephone survey consisted of a random sample of all Roanoke registered voters, only limited evidence on how those in this study voted in the referendum was obtained.

[25] The PDA and hedonic price estimates were deflated to 1987 dollars using the CPI for shelter expenditures in order to be comparable with the CVM estimates.

observations. In addition, most comparison studies have also been limited by the lack of direct corroborating evidence from actual revealed choices. The CVM and PDA can be classed as hypothetical choice techniques because benefits are estimated from speculations made by survey respondents (CVM) or analysts (PDA). While the hedonic price technique, as well as the travel cost method, derives benefit estimates from actual choices, the hedonic price method is termed an "indirect" revealed choice technique because the monetary value individual's place on flood risk reduction is embedded along with other attributes in the price of a given property. The few studies which have compared hypothetical choices with actual behavior were carried out in experimental settings and using tradeable or private goods (Dickie, Fisher, and Gerking 1987; Neill *et. al.* 1994; Bishop and Heberlein 1979, 1990).[26] To date there has not been a study which compares actual and hypothetical choices concerning a nonmarket good in a nonexperimental setting. This study is able to compare the indirect revealed choice and hypothetical choice methods with direct revealed choice behavior in the Roanoke bond referendum concerning a nonmarket good.

8.3 Benefit Estimate Comparison for Identical Properties

Mean benefit estimates by flood zone for the three methods were computed and are presented in Figure 8.1. Two results are immediately apparent. First, the hedonic price estimates exceed the CVM and PDA estimates for most flood zones, with the gap between estimates greatest for the most flood prone areas.[27] In the 20 to 50 year flood plains, the hedonic price estimates are 2 to 3 times greater than the PDA estimates and dwarf the CVM estimates. For the 100, 500, and 1000 year flood plains, the hedonic estimates are more similar to mean CVM bids but are still many times greater than PDA estimates. Second, mean CVM bids exhibit an unexpected pattern across flood zones.[28] Since those subjected to the most frequent flooding stand to the most to gain in property and nonproperty effects from the a reduction in flood risk, the expectation is that estimated benefits will be largest for those closest to the river, i.e., those located lower in the flood plain. The PDA and hedonic price estimates of the benefits from flood protection fell as the property was farther from the river, the expected pattern. Mean CVM bids, however, did not follow this pattern and are lowest for landowners closest to the river.[29]

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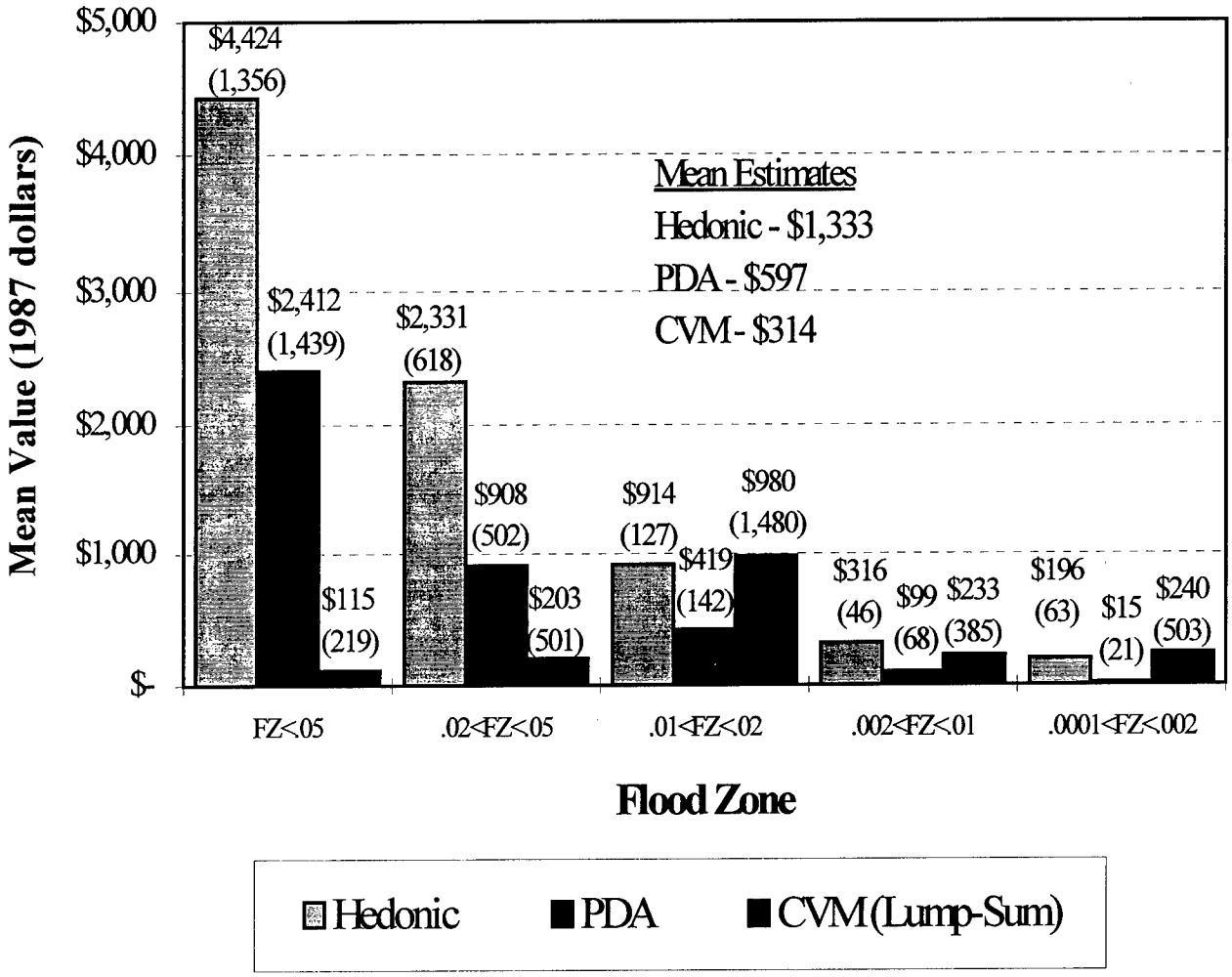
[26] For a comprehensive summary of this literature see Smith (1993), Hanemann (1994), and Diamond and Hausman (1994).

[27] In order for the CVM to be comparable to the hedonic and PDA estimates, the lump-sum WTP bids will be used in the benefit estimate comparison. The comparison of CVM with voting behavior, however, will use the CVM annual payment WTP bids. The annual WTP format more closely resembled the way citizen's were asked to pay for the project in the Roanoke referendum.

[28] Mean CVM bids shown in Figure 8.1 include all protest and uncertain bids (which are zero). As discussed below, excluding protests bids does not significantly change the general pattern shown in Figure 8.1 and does not alter the conclusions of this report.

[29] It should be noted, however, that the hedonic benefit estimates fell as the property was farther from the river partly because of the log-log functional form of the estimated hedonic price equation.

Figure 8.1: Mean Values of Estimates by Flood Zone *



* Standard deviations are in parenthesis

8.3.1 A Closer Look at CVM Estimates

In many respects, the CVM offers many potential advantages over the PDA and hedonic price methods in measuring flood control benefits by providing the respondent with information of flood risk, capturing nonproperty aspects of flood hazard reduction, and providing theoretically consistent estimates from nonmarginal changes in flood risk. Yet, researchers have identified a number of potential biases associated with the CVM, hypothetical biases one of the most intractable of these biases. Evidence shown in Figure 8.1 warrants a closer look at the CVM results.

The mean lump-sum CVM bids reported in Figure 8.1 include all protest bids and uncertain bids, both of which were entered as zero. Of the 73 survey respondents included in this analysis, 18 "protesters" would not respond to the willingness to pay questions, and 11 "uncertain" could not respond to the willingness to pay question. The "protesters" objected to the willingness to pay question on a number of grounds but in general most objected to being asked that they pay for the project (see Appendix A). For instance, many felt that they had suffered enough from flooding and that someone else, such as the federal government, should pay for the project.[30] In addition to the "protesters" about 15 percent of all respondents were simply unable to provide a willingness to pay bid, even when prodded by the interviewer, these being labeled "uncertain" bidders. Presented the task of "purchasing" something so unfamiliar as a reduction in flood risk, many respondents stated that they had no basis for making such bid even when given a payment card.

The distribution of protest, uncertain, and total lump-sum CVM bids across flood zones is listed in Table 8.1. The distribution of "protesters" was fairly constant across flood zones with roughly a fourth of all survey respondents registering a protest vote. On the other hand, those living closer to the river appeared to be more likely to have been unable or unwilling to make a bid, i.e., "uncertain" respondents.

Table 8.1: CVM Protest and Uncertain Bids By Flood Zone (Lump-sum Bids)

FLOOD ZONE	Number of Protest Bids	Number of Uncertain Bids	Total Number of All Bids
FZ < .05	3 (27%)	2 (18%)	10
.02 < FZ < .05	2 (13%)	5 (33%)	15
.01 < FZ < .02	2 (20%)	0 (0%)	10
.002 < FZ < .01	3 (23%)	1 (8%)	13
.0001< FZ <.002	8 (32%)	3 (12%)	25
ALL FZ	18 (24%)	11 (15%)	73

The exclusion of protest or uncertain bids changes the magnitude but not the overall pattern of WTP bids across the flood zones. Table 8.2 summarizes the mean CVM bids by "flood zone" including all bids, excluding just uncertain bids, and excluding protest bids and unanswered bids. As the Table 8.2 shows, the same general pattern shown in Figure 8.1 holds whether or not protest

[30] Other respondents who provided a positive WTP bid, also questioned the "fairness" of asking the flood victim to pay for the project.

bids and uncertain bids are included in the analysis.[31] Regardless of whether protest or answered bids are included, average willingness to pay bids were still lowest for properties closest to the river.

Table 8.2: CVM Lump-Sum WTP Bids By Flood Zone

	CVM Bid Range		Mean CVM Bids		
FLOOD ZONE	Min.	Max.	All Bids	Excluding Uncertain Bids	Excluding Uncertain & Protest Bids
FZ < .05	0	600	115.00	143.75	230.00
.02 < FZ < .05	0	2000	203.33	305.00	381.25
.01 < FZ < .02	0	5000	980.00	980.00	1225.00
.002 < FZ < .01	0	1500	223.08	241.67	322.22
.0001< FZ <.002	0	2000	240.00	272.72	428.57
ALL FZ	0	5000	310.81	365.08	511.11

Table 8.3 shows the average annual payment WTP bid across flood zones. Like the distribution of lump-sum bids, the mean annual WTP peaked some distance from the river.[32] Regardless of how the average bids were calculated, respondents in the 20 and 50 year flood plain each provided the lowest WTP bids of all respondents. Excluding all protest and uncertain bidders, annual WTP averaged $30 and $39.87 for those living closest to the river. Those living in the 500 and 1000 year flood plains were willing to pay about twice as much as those in the 20 and 50 year flood plain. Although the primary beneficiaries of the flood control project, the landowners closest to the river were simply unwilling or unable to pay for the project - regardless of how the CVM bids were aggregated and regardless of whether the lump-sum or annual payments bid formats were used.

[31] While the 100 year flood plain has the highest mean willingness to pay, the largest WTP bid ($5000) was also given by a respondent in this flood zone. Excluding this bid, the average falls from $980 to $533. Thus, regardless of whether this bid is included or not, mean WTP still peaks in the 100 year flood plain.

[32] The responses between the lump-sum and annual payment methods were almost always consistent. Only in 5 cases (out of 74) did the respondent switch WTP responses due to the different payment method. In the 4 of 5 instances of switching, respondents who registered a positive bid in the lump-sum scenario protested the annual payment question. These four respondents objected to the annual payment because they were either old or planning to sell their property (see Appendix A.4).

Table 8.3: CVM Annual Payment WTP Bids By Flood Zone

	CVM Bid Range		Mean CVM Bids		
FLOOD ZONE	Min.	Max.	All Bids	Excluding Uncertain Bids	Excluding Uncertain & Protest Bids
FZ < .05	0	75	14.00	17.50	28.00
.02 < FZ < .05	0	100	21.27	31.90	39.87
.01 < FZ < .02	0	550	158.00	158.00	175.56
.002 < FZ <.01	0	250	41.54	45.00	67.50
.0001< FZ <.002	0	150	28.20	32.05	64.09
ALL FZ	0	550	44.99	52.97	80.09

The unexpected pattern of willingness to pay bids across the flood plain raises concerns about the credibility of the CVM results. One of the primary criticisms of the CVM is that benefit estimates are based on speculative answers to a hypothetical situation. The validity of CVM is dependent on the assumption that respondent's hypothetical response would be converted into behavior if the hypothetical CVM scenario were to actually happen. The landowners had an opportunity in the well publicized single issue bond referendum to vote for the project and impose only a small tax on themselves. The bond would be used solely to help finance the same flood control project that was described to the CVM survey respondents a year and half earlier.

Table 8.4 reports on voting behavior in the referendum for those who provided positive, zero, and "uncertain"/"protest" bids in the CVM study. First, 31 people bid positive amounts for the annual payment willingness to pay question in the CVM hypothetical survey. However, only 10 (32 percent) of these same individuals bothered to vote in the election. Those who said the flood control project was of no value to them, i.e., "zero bidders," were about as likely to vote as those who made positive bids (4 of 11 respondents). Of the three groups of CVM bidders, the "protesters"/"uncertain" bidders was the group most likely to have voted (14 of 32 bidders). Thus, those most likely to object to some facet of the CVM study were the most politically active in the flood control referendum. The results shown in Table 8.4 cast doubt on whether expressions of willingness to pay in hypothetical CVM bids translate into actual choice behavior.[33]

[33] There is some limited evidence on how those who went to the polls actually voted. The telephone survey of registered voters described in Section 7 contacted 14 out of the 28 who voted in the referendum. Of these 14 people, 9 gave positive WTP bids, 1 bid zero, and 4 protested. The zero bidder and 3 of the 4 protest bidders voted for the project. Of the 9 positive bidders, 7 voted in support of the project. The two positive bidders who opposed the bond issue stated annual WTP bids of $150 and $25. Thus, only 8 of the 14 interviewed respondents voted in a manner unambiguously consistent with their WTP bids.

Table 8.4: CVM Annual Payment Bids and Voting Behavior: Number of Respondents

CLASS	CVMBID > 0 "Positive"	CVMBID = 0 "Zero"	"Protest & Uncertain"	Total
Registered and Voted	10	4	14	**28**
Registered and Did Not Vote	4	1	12	**17**
Not Registered	16	6	6	**28**
TOTAL	**30**	**11**	**32**	**73**

Table 8.5 shows the mean annual WTP bids for those who voted, those who were registered to vote but did not, and those not registered to vote. Considering all CVM respondents, the average WTP bids of those not registered to vote were more than double of those who did vote. On average, those not registered to vote stated they would pay $71 for the flood control project, while the voters were willing to pay just $33 each year. If only the positive bidders are considered, those not registered to vote stated in the CVM interview that they would be willing to pay over $124.37 each year for 15 years for project construction. Thus, those who bid the most for the flood control project were unlikely to actually vote when they had the opportunity to reveal their preferences.

Table 8.5 CVM Annual Payment Bids and Voting Behavior: Average Bids

CLASS	Positive Bidders	Positive & Zero Bidders	All Respondents
Registered and Voted	$92.90	$66.35	**$33.18**
Registered and Did Not Vote	$91.25	$73.00	**$21.47**
Not Registered	$124.37	$90.45	**$71.07**

8.3.2 PDA and Hedonic Price Estimates

The other striking result from the comparison of benefit estimates shown in Figure 8.1 is the magnitude of the hedonic estimates. What accounts for this large difference between the hedonic estimates and PDA and CVM estimates? First, consider the relationship between PDA and hedonic estimates. The PDA method is likely to underestimate total benefits since the assumptions of risk neutrality and no nonproperty benefits are, in all likelihood, violated. The results of both the voting and CVM studies suggest nonproperty benefits are a significant component of total benefits. The relationship between PDA and hedonic estimates appear to confirm that nonproperty benefits are a significant component to the total benefit estimates. Across the four of the five different flood zones, the hedonic price estimates are consistently 2 to 3 times greater than the PDA estimates.[34] Yet, these conclusions do not conform with the CVM results. While CVM conceptually captures all property and nonproperty effects of reduced flood risk, the CVM bids yielded the lowest mean benefit estimates of the three techniques as displayed in Figure 8.1.

The hedonic estimates appear to account for property and nonproperty benefits in a consistent pattern across the flood plain. Yet, the magnitude of bias and sensitivity of the hedonic

[34] The exception is the 1000 year flood plain. The hedonic estimate is larger than the PDA estimate by a factor of 13.

estimates raise many questions about the reliability of the hedonic results. As discussed in Section 5, the hedonic price technique will overestimate flood reduction benefits for nonmarginal changes in flood risk. In the more flood prone areas, the project is expected to substantially reduce the threat of flooding. Although the magnitude of the bias is unknown, some additional research in the Roanoke case study suggests that hedonic estimates could overestimate total willingness to pay in the 20 year flood zone by as much as $1,500 (Dietz 1992). Perhaps much more damaging problem of the hedonic techniques is that benefit estimates are derived from the outcome of land market trades. Land market traders may possess only limited information about the consequences and probability of flood events. Recall that prior to the 1985 flood, the statistical analysis described in Section 5 found no evidence that land traders considered flood risk in buying and selling property in the Roanoke study area. If a hedonic price study was conducted in 1984, the benefit estimates from a reduction in flood risk would have been zero across all five flood zones.

SECTION 9
IMPLICATIONS AND RECOMMENDATIONS

The performance of the three benefit estimation techniques can be evaluated based on three criteria: consistency, reproducibility, credibility. Consistency here refers to how well the final benefit estimates of each method match the neoclassical economic model of choice behavior described in Section 2 of this report. Methods that generate willingness to pay estimates consistent with neoclassical economic choice theory can be thought of as generating conceptually valid measures of welfare change. Reproducibility refers to whether the method generates similar results in repeated applications.

Credibility means that the benefit estimation procedure generates estimates that are easily interpreted and understood by decision participants. Also, the estimate should provide insights into some salient feature of choice. A credible technique is also in some sense related to how well a technique meets the reproducibility criteria.

9.1 Consistency of the PDA, Hedonic Price, and Contingent Valuation Methods

All three methods can be evaluated against the neoclassical economic model of choice behavior. This framework justifies interpreting people's choices to infer and then monetize their preferences. If individuals have well-ordered and stable preferences for alternative states of the world and choose according to those preferences, subject to income and price constraints, then buyers and sellers will equate their expected marginal utility for traded goods and services to market prices. Consequently, prices reflect marginal valuations and provide empirical data for preference measurement. Absent market price interpretation of prices paid or received for related goods and services, through PDA or hedonic price, or stated choice intentions on a CVM survey provide the basis for value inference.

As demonstrated in Section 4, a number of assumptions must be made if PDA can be interpreted as a measure consistent with the willingness to pay conceptual standard. Many of these assumptions, e.g., the property owner possesses the planner's understanding about the probability and consequences of flooding and has a time horizon, risk attitude, and discount rate equivalent to that used by the analyst, are necessary since benefit estimates are not based on observed individual assessments of the flood risk. For instance, the results from the CVM and voting studies offer strong evidence that non-property benefits, which are ignored in the PDA approach, are significant in the support of flood risk reduction projects.

Unlike PDA, the hedonic price and contingent valuation methods both rely on flood plain residents and landowners subjective assessment of the value of reduced flood risk to generate benefit estimates. Before hedonic price and CVM estimates meet the consistency criteria, each method must translate stated hypothetical or indirectly revealed choices, through observed purchases of related market goods, into estimates consistent with the conceptual willingness to pay standard. Thus, much attention is also focused on whether CVM or the hedonic price method can generate conceptually "complete" or "unbiased" measures of willingness to pay. The contingent valuation literature has focused attention on the many potential biases associated with the measurement technique, i.e., hypothetical, nonresponse, payment method, and strategic biases, and

has directed professional attention to addressing these potential limitations. Similar concerns have been expressed about the hedonic price method. For instance, it is frequently noted that the hedonic price method generates upwardly biased estimates for nonmarginal changes in flood risk (Freeman 1979; Driscoll, Dietz, and Alwang 1994).

Thus, some of the differences in benefit estimates of the three methods could be interpreted as limitations of the measurement instrument that causes deviations from the conceptual willingness to pay standard. For instance, the hedonic price method may overestimate flood risk reduction benefits in the most flood prone areas. Thus, the large hedonic price benefit estimates in the most flood prone areas could be attributed to biases associated with nonmarginal changes in flood risk. Similarly, hypothetical bias may be responsible for divergences between observed voting behavior and CVM willingness to pay responses. Many CVM study participants did not carry their expressions of willingness to pay from the hypothetical setting of the survey into the voting booth. The PDA estimates could be low given the potentially large nonproperty benefits. However, given that a variety of assumptions could be violated, it cannot be stated with certainty whether PDA is under- or over-representing total willingness to pay.

9.2 Reproducibility of the PDA, Hedonic Price, and Contingent Valuation Methods

While each method may not completely meet the consistency criterion, do these three methods generate similar benefit estimate patterns across similar projects? PDA will tend to meet this reproducible criterion because the underlying basis for calculating estimates, i.e., statistical, "objective" estimates of flood risks, repair costs as measures of damages avoided, discount rates, etc... do not change across analyses. Some behavioral decision research, however, has cast doubt on the ability of CVM and hedonic price methods to generate reproducible WTP estimates on more fundamental grounds. It is argued here that many of the conflicting results may arise not only from the limitations of the measurement instruments but *from the assumptions surrounding the economic model of choice.* The inconsistencies evident in both the hedonic price and contingent valuation methods can be partially traced to the lack of correspondence from the way people actually make choices and the way they are conceptually modeled.

According to this viewpoint, the way people actually go about forming and revealing preferences bears little resemblance to the behavioral assumptions upon which the CVM and hedonic price method is founded. Since the CVM and the hedonic price method are based on the neoclassical economic model of choice described in Section 2, each method assumes that people have a consistent and complete set of preferences for market and nonmarket goods and that these methods can uncover these preferences (Kahneman 1986).

A growing body of literature has demonstrated that preferences orderings often conflict and are formed and revealed in a mental process far different than assumed by the advocates of the CVM (Schkade 1996). Critics of the economic model of choice stress choices are made by "human beings" who have unstable, inconsistent, incompletely evoked, and imprecise goals at least in part because of human inabilities to limit preference orderliness (March 1978). Psychologists have noted when choices are made in complex, unfamiliar, uncertain and limited information conditions, people do not retrieve previously formed preferences as much as "construct" preferences in the context of specific choice circumstances (Fischoff 1991; Slovic, Griffin, and Tversky 1990). If

preferences vary across time and between choice-making circumstances, then differences between benefit estimates generated by methods which rely on indirectly revealed or stated preferences, hedonic and CVM respectively, should be expected (Shabman and Stephenson 1996). Given this perspective, the ability of the CVM and hedonic price methods to generate reproducible benefit estimates maybe limited.

The cognitive limitations of humans in dealing with highly complex and uncertain concepts associated with valuing a reduction in flood risks was highlighted by the CVM and hedonic price methods. During the CVM interview process, the cognitive demands of placing a monetary value on the reduced probability of flooding was enough for 15 percent of the respondents to give up trying to even come up with a WTP bid. Many respondents had a difficult time attempting come up with a willingness to pay bid despite the fact that the consequences of flooding and the flood control project were familiar and had a direct effect on their lives. Valuing unfamiliar topics where outcomes are not directly experienced is thought to entail the most cognitive problems (Fischoff 1991; Schkade 1996).

The hedonic price model revealed that landowner's assessment of the flood probability bore little resemblance to "objective" statistical concepts. Prior to the 1985 flood, the probability of flooding appeared to have played little part in evaluating the value of properties in the flood plain. Although the probability of flooding was still the same after the 1985, the value of more flood prone properties only was depressed after 1985. In this study, land market traders appear unable to understand flood potential without some major flood to anchor their perceptions. These findings are consistent with results from controlled laboratory experiments designed to solicit measures of subjective probability of natural hazards. This research suggests that for natural hazards, low probabilities are, at some point, assigned a zero value. Thus, the objective probability of loss is ignored (Slovic et. al. 1977; Schoemaker and Kunreuther 1979). Kunreuther (1985) argues that unlike technological risks, people generally "focus on the low probability aspect of a natural disaster, claiming 'it won't happen to me.'" When a natural disaster occurs, evidence in Roanoke suggests that people may then overreact, overestimating the probability of future floods. These findings mirror those of Kask and Maani (1993) who found that hedonic estimates are highly sensitive to the market trader's level of experience and information about the natural hazard, holding the objective probabilities constant. Tobin and Montz (1994) report that severe flood events will alter property values. The important point here is that for low probability events like flooding, the magnitude of benefits estimated using the hedonic price technique will depend on the timing of a hedonic price study vis-a-vis the scope and date of the last flood. It would be reasonable to hypothesize that the magnitude of CVM bids would also be dependent on the timing of the study regardless of the quantity or quality of objective information provided to the respondent.

Preferences may also change according to the context in which a problem or question is presented. Contingent valuation studies often force people to value a nonmarket good in an unfamiliar context. People are unaccustomed to thinking about nonmarket goods in a market context and have no experience valuing such goods in such a context. The actual providing of nonmarket goods is usually undertaken in the political arena, and it is within this context that people form values about nonmarket commodities. Evidence from the Roanoke bond referendum suggests that many city residents paid very little attention to what the project was going to cost

them. The project supporters tended to vote for the project in order to help others who suffered from flooding. Opponents tended to feel the project was not the best solution to the flooding problem. What is germane to the discussion here is that consideration of the required tax payment received very little of the voter's attention. Although each household received an information brochure from the city prior to the election outlining the proposed project and the details of the project were well publicized in the local media, 20 percent of the voters did not know how the project was going to be paid for. Another 33 percent knew their taxes were going to increase but had no idea by how much. Further details concerning this information problem are described in Section 7. [An even larger percentage of those who were registered but did not vote know about the tax increase.] The actual decision process for the citizens of Roanoke revolved more around the moral and civic issues. Attaching monetary consequences to the decision did not appear particularly important when preferences were constructed in reference to the flood control bond referendum.

Thus, CVM scenarios usually involve descriptions of complex descriptions of complex problems in unfamiliar contexts. In such situations, respondents often attempt to simplify or redefine the problem into a more manageable form or into a form that they find more understandable or acceptable (Schkade 1996; Schkade and Payne 1994). Evidence in the Roanoke CVM study suggests that how the flood protection was going to be paid for was as important as how much flood protection was provided. To many of the respondents, the relevant question was not "What am I willing to pay for reduced flood risk provided by the flood control project?" but rather "Who should pay for the project?" Undeniably bound to this latter question was the issue of fairness. The general feeling among many respondents who both participated in and protested to the CVM willingness to pay question was that it seemed unfair to ask those who suffered the most financial loss and personal hardship to pay for the project. The fairness issue is one of the most plausible reasons why willingness to pay for flood protection was the lowest for those living nearest the river. Since there is no established set of criteria for choosing how a given commodity like flood protection should be provided and paid for in a hypothetical CVM market, benefit estimates should be expected to vary significantly depending on what particular questions are asked.

Thus, the evidence in this case study supports the proposition that preferences are in some degree time and context dependent. Consequently, the contingent valuation and hedonic price methods are likely to generate different results, perhaps widely different results, depending on when and in what context the study was done. Furthermore, generating reproducible results will unlikely be achieved with refinements in the method.

9.3 Credibility of the PDA, Hedonic Price and Contingent Valuation Methods

The credibility of a particular method is related to a number of factors including the ability of the technique to generate similar results across similar projects and economic conditions. If a method yields a logical, expected pattern of estimates in repeated applications, analysts and other decision participants will be more likely to find the results understandable and acceptable. The best that can be said for the benefit comparisons described in Section 7 is that the PDA approach did follow an appealing logic as benefits fell with distance from the river. Furthermore, the PDA would generate similar estimates regardless of the timing of the study. This was not the case with either the CVM or hedonic technique. The CVM estimates were lowest for precisely those most likely to

gain the most from flood protection. The hedonic price method would have generated either a very high total benefit estimate or a zero total benefit estimate depending on whether study was done before or after the 1985 flood.

A credible technique should also shed some insight into some important aspects of project choice. PDA benefit estimates since the late 1930s have been used because they flowed easily from the available hydrologic information, they have an appealing "investment logic," and they were adaptable to the political process which ranked projects. For a method to be useful, however, it is not necessary for the method to generate a comprehensive benefit measure if the limitations are well understood. The PDA has never been treated as an accurate measure of because the narrow focus of PDA on property damages has long been recognized. Investment priorities were expected to recognize a variety of social objectives that might be served by flood risk reduction, including relief of human suffering and encouraging development of flood plain lands for agricultural and commercial uses. PDA estimates have been an initial screen to determine project worth, but the benefit computations never have been, and were never intended to be, the final factor determining project choice.

9.4 Recommendations

The more fundamental question is whether any measurement of benefits can be expected to be more than a rough guide to beginning and structuring the necessary collective choice decision on flood risk reduction. With this perspective, no estimate is the "correct" measure of benefits and no estimate should be expected to be "correct." Recall how benefit estimates have been used for guiding flood control investments in the past. The early applications of the land price method were expected to only roughly approximate willingness to pay. The benefit estimation effort was the basis for negotiations between landowners and flood control districts on mutually acceptable assessments to pay for project construction (Shabman 1989).

If this perspective on benefit estimation is adopted, then any suggestion to apply the CVM or hedonic approach will need to be defended by demonstrating which method contributes to a better understanding of project effects and to reaching political agreements. Based on this perspective, the estimation methods should not be based on which one generates the most "consistent" measure of willingness to pay but rather selected on the bases of whether the method and results are credible by those with a stake in project negotiations.

The benefit estimation method which generates reproducible and credible results is then less likely to be the source of confusion or controversy among the participants. However, based on the evidence from this study, the CVM and hedonic price method generate results that might not be viewed as credible by those involved in political negotiations. At present there seems to be little reason to deviate from PDA benefit estimation as long as the limitations of the benefit estimates are recognized when making flood control investment decisions.

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APPENDIX A

CONTINGENT VALUATION SURVEY AND PROCEDURES

APPENDIX A.1
TEXT OF LETTERS SENT TO RESPONDENTS

The following letters were mailed to the survey respondents. The first letter was mailed on August 21, 1987. The first letter was an introductory letter to inform the respondents that a survey was to be conducted in their area. The second letter was sent on September 10, 1987 to those respondents that could not be contacted by telephone to arrange an interview or had an unlisted phone number. The third letter was mailed on October 3, 1987. The third letter was mailed to those respondents that did not respond to the second letter. The third letter was the final letter sent to the landowners and was intended to identify the survey respondents that were not willing to participate in the survey.

Letter One, Mailed August 21, 1987

As you may know the United States Army Corps of Engineers, in cooperation with the City of Roanoke, is planning a flood control project for the Roanoke River. The proposed project will reduce the chance of flooding in many neighborhoods within Roanoke. Your house is within the project area.

The Corps of Engineers has chosen the Roanoke River flood control project, from among several alternative areas nation-wide, as an area to review its flood control planning activities. The Corps has asked the staff at Virginia Tech to survey residents in the Roanoke area about their views and concerns over flooding and flood control.

Staff from Virginia Tech will be in your area conducting a survey of homeowners. Within the next week someone will telephone you to set a date and time when an interviewer can visit with you. The interview will take no more than one half hour of your time.

Your participation in this survey is voluntary. However, the results of this study will have an important effect on flood control efforts in the United States. Your participation in this effort will be greatly appreciated.

If you have any questions or concerns about this study please do not hesitate to contact me (Eric Thunberg) at (703) 961-7814. Thank you for your time.

Sincerely,

Eric Thunberg
Project director

Letter Two, Mailed September 10, 1987

Last week you should have received a letter explaining that a survey is being conducted about flooding of the Roanoke River and the flood control project that is being planned for the City

of Roanoke. That letter indicated that I would be contacting property owners such as yourself to set a date and time for a personal interview. Because I have been unable to reach you by telephone, I would appreciate your calling me collect at (703) 961-7814 between 8 am and 5 pm Monday-Friday to arrange a convenient time for an interview. If I am unavailable please leave you name and a number where you can be reached and I will return your call.

I look forward to your call.

Sincerely,

Eric Thunberg
Project director

Letter Three, Mailed October 3, 1987

My name is Eric Thunberg and I am a research assistant at Virginia Tech. You should have received a letter from me describing a survey that is being conducted in the Roanoke area with regard to the flooding of the Roanoke River and the flood control project that is being planned for the river. If you did not receive the letter please accept my apologies. At this time I am asking if you would be willing to participate in the survey and would like to arrange a date and time that I can come to your house and interview you. Your participation is voluntary, but is very important that all individuals' views on flooding and flood control are represented. Please take a moment to fill out the form below and return this letter to me in the stamped envelope I have provided. If you have any questions please call me collect at 1-961-7814.

I look forward to hearing from you

Sincerely,

Eric Thunberg
Project director

_____I am not willing to participate in the survey.
_____I am willing to participate in the survey.
I can be reached at_____(phone number) during the hours of _____.

APPENDIX A.2
THE SURVEY QUESTIONNAIRE

Design of the Survey Questionnaire

The survey questionnaire was subjected to an extensive review by experts in survey design and was pre-tested. In response to these reviews and the pre-test, the questionnaire underwent several modifications. The major revisions that were made in response to reviewer comments are as follows. First, the questionnaire was modified to reflect more of a real-life situation. Second, the language of the questionnaire was simplified. Third, a payment card approach was adopted. Fourth, the number of trauma questions was reduced. Fifth, the community effects of the project were described in relation to an experienced flood event, e.g., the 1985 flood. Sixth, the flood probabilities were redefined in terms of one with- and one without-project chance of flooding in a ten-year period. The major revisions that were made in response to the pre-test are as follows. First, individuals anchored their bid for the annual payment on what they had bid in a lump sum. A transitional phrase was added asking the respondent to imagine that the previous bidding sequence had never taken place. Second, questions about flooding probabilities were mistaken as asking whether the respondent agreed with the Corps' estimate of flood probabilities. These questions were dropped and the with- and without-project flood probabilities were included as part of the project description. Third, the pre-tested respondents became alarmed when asked to pay for the project. A new preamble to the bid question was written to make it clear that while the financing arrangements were not complete the study results would not be used to make any such decisions. The language of this preamble was later revised to eliminate any references to a hypothetical situation.

Survey Questionnaire

OMB #0702-0016
expires 31/Oct/1989

House ID HID 1-159	Owner Occupied O/R = 1 Rental O/R = 0
Flood Zone:	FZ = 1 - 7
First Contact Attempt:	Not Coded
Call Back Date:	Not Coded
Interview Date:	Date = 2 - 1015
Start Time:	Not Coded
Interviewer:	Not Coded

Introduction

Hello, My name is _____. I am a research assistant at Virginia Tech. I am here to ask you some questions about your feelings and attitudes toward flooding of the Roanoke river in your area.

This study is sponsored by the Army Corps of Engineers who plan to use the results to improve the planning of other flood control projects throughout the nation. Your participation in this study is voluntary, and you may refuse to answer any question. At your request the interview will be terminated. However, your participation is very important to the successful completion of this study. The information that you provide will be kept strictly confidential, and only reported in statistical summaries. It should take about 30 minutes to complete the interview.

Before I continue do you have any questions?

As we proceed please keep in mind that there are no right or wrong answers in this survey. Only your personal views about river flooding and flood control are important for this interview.

1. How long have you lived at your current address? (1 - 62) years _____months. Q1

2. Have you ever experienced flooding of your home either at this address or at another address? Q2

   (1) yes

   (0) no

3. Was your home flooded during the November 1985 flood? Q3

   (1) yes

   (0) no -- if no go to question 9

   Please answer the following questions for the November 1985 flood.

4. Using the scale on the card I am showing you, how would you describe the amount of damage done to your residence, furnishings and personal possessions? Q4

   None Very Bad

   0 1 2 3

5. Did you loose objects of sentimental value in the flood? Q5

(1) yes

(0) no

6. Did you or any member of your household require medical attention or counseling services because of the flood? Q6

(1) yes

(0) no

7. Did you receive any type of insurance payment, disaster relief payment or free medical attention after the flood? Q7

(1) yes

(0) no

8. Using the scale on the card I am showing you, how would you describe the long term effect of the November 1985 flood on the quality of life in this community. Q8

very negative effect		no change		very positive effect
-2	-1	0	1	2

There is a chance that this neighborhood will be flooded in the future. I am going to describe some emotions you may feel about the possibility of future flooding in this neighborhood. Using the scale on the cards I will show you please indicate the effect of flooding on your feelings.

9. The possibility of flooding in this neighborhood makes me feel Q9

not at all helpless			very helpless
0	1	2	3

10. The possibility of flooding in this neighborhood makes me feel Q10

not at all afraid very afraid

0 1 2 3

11. The possibility of flooding in this neighborhood makes me feel Q11

not at all depressed very depressed

0 1 2 3

12. Do you feel anxious, nervous or upset when flood warnings are issued? Q12

No, not at all very upset

0 1 2 3

As you may know, a flood control project is being planned for the portion of the Roanoke River that runs through the City of Roanoke. The project that has been selected will reduce the chance that the river will flood and will reduce the depth and the length of time a flood lasts if one occurs. The effect of the project in the City of Roanoke will be to eliminate or reduce flood damage to homes, personal belongings, yards and gardens and flood related injuries.

13. From the list I am showing you what do you feel are the three most important reasons for providing flood control? Q13a Q13b Q13c Q13d

(1) reducing damage to house
(2) reducing damage to personal belongings
(3) reducing damage to yard and/or garden
(4) reducing emotional stress about future flooding
(5) reducing chance of personal injury
(6) reducing the disruption of the community
(7) other_____(specify)
(9) = not applicable

Now I am going to describe the affects that the project will have on the community of Roanoke.

The flood of November 1985 was one of the largest floods recorded for the Roanoke River. That flood disrupted the lives of thousands of people in the Roanoke valley. Over 5,000 houses were damaged. Many businesses were damaged as well and were forced to close, some never reopened.

Several bridges and roads were closed for days or weeks after the flood making travel around the city difficult and causing many people to lose time at work.

If a similar flood were to occur again, on average, flood damages to Roanoke residents and businesses would be reduced by nearly one half and critical facilities such as the Roanoke Memorial hospital would be completely protected. In this area, from the hospital to the 9th street bridge, for the 150 homes lying closest to the river, after the project is built if a flood similar to the 1985 event were to occur, flood damages would be expected to be three quarters lower than they would be if no project is built.

Do you have any questions about the affect of the project on potential flood damages in the Roanoke community and in this neighborhood?

(if yes prompt)

14. Based on what I have told you about the project which of the following statements best describes how you feel the project will affect the welfare of this community?

Q14

I feel that the project will have a

(0) negative affect on the welfare of this community.

(1) no affect on the welfare of this community.

(2) small, positive affect on the welfare of this community.

(3) moderate, positive affect on the welfare of this community

(4) large, positive affect on the welfare of this community.

(9) = no answer

Floods both larger and smaller than the November 1985 flood can occur in the future. All these possible floods are considered in planning a project to protect all properties along the river. Therefore, in their planning the Corps has calculated the chance of flood waters entering the first floor or basement of your residence both before the project is built and after it is built.

I am going to describe how the project changes the chance of flood waters entering the first floor or basement of this residence at least once in the next ten years.

If no flood control project is built there would be a ( )% chance that flood waters would enter the first floor or basement of your house at least one time in the next 10 years.

After the project is built the chance that flood waters would enter the first floor or basement of your

house at least one time in 10 years will be reduced to ( )%.

Do you have any questions about how the project will affect the chance of flood waters entering your house at least one time in the next ten years?

(if yes prompt question)

15. Based upon what I have told you about the project's effect on flooding at your house, which of the following statements best describes what you feel the project will do for you? Q15

    The project will:

    (0) increase the chance of flooding at my house.

    (1) not affect the chance of flooding at my house.

    (2) slightly reduce the chance of flooding at my house.

    (3) moderately reduce the chance of flooding at my house.

    (4) greatly reduce the chance of flooding at my house.

    (5) eliminate the chance of flooding at my house.

    (9) = no answer

16. Based upon what I have told you about the project, which of these statements best describes what you think will happen to property values in your neighborhood after the project is completed? Q16

    Property values will:

    (0) go down.

    (1) not change.

    (2) go up a little.

    (3) go up moderately.

    (4) go up a lot.

    (5) Do not know or uncertain.

17. Do you have flood insurance? Q17

(1) yes

(0) no -- if no, go to page 8

18. Based upon what I have told you about the project, which of these statements best describes what you think will happen to your flood insurance premium after the project is completed? Q18

Flood insurance premiums will:

(0) go up.

(1) not change.

(2) go down a little.

(3) go down moderately.

(4) go down a lot.

(5) Do not know or uncertain.

(9) = not applicable

The flood control project I just described will cost money. The cost of the project will be shared between the City of Roanoke and the Federal government. The arrangements to pay for the project have not yet been completed.

I will present you with two different ways the project might be paid for. Based on what you think the project is worth to you, I will ask you to tell me how much you would be willing to pay for the project.

(If the respondent is unwilling say:)

At this time I am not asking for any payment from you. All final decisions with regard to payment for the project will be put to a city-wide referendum.

Your response will be kept strictly confidential

(If the respondent is still unwilling say:)

The payment questions are hypothetical. This study is being conducted solely for the Corps

of Engineers for the purpose of reviewing their planning procedures. The results of this study will not affect any aspect of the project being planned for the Roanoke area.

Payment Method 1: A One-Time Payment

19. Suppose that the cost of the project will be paid by property owners (commercial and residential) as a one time only special assessment as soon as the project is built.

Here is a card with amounts of money on it (Hold up card). What is the most you would be willing to pay as a one time assessment to help pay for the flood control project? In your response feel free to select any number displayed on the card or any number that lies between, or is greater than the displayed amounts.

0	50	75	100	125	150
200	300	400	500	600	700
1000	1200	1400	1600	1800	2000
2500	3000	3500	4000	4500	5000

Bid 1 -- write the bid here 0 - 5000 -- if 0 go to 20. Q19a

If the amount you just told me was not enough to build the project and the project would not be constructed unless enough money was collected, would you be willing to pay more?

( ) yes -- if yes, go to Bid 2

( ) no

Bid 2 -- How much more would you be willing to pay for the project in a one-time payment? $_____. Q19b

(SUM BID1 + BID2 _____) Is $_____ what you would be willing to pay for the project? Q19c

( ) yes

( ) no -- if no, go to Bid 3

Bid 3 -- Between $(response for bid 1) and $(bid 1 + bid 2) what is the most you would be willing to pay for the project in a one time assessment?

20. PROTEST 1 -- If willingness to pay = 0 Q20

We have found in studies of this type that people have a lot of reasons for answering as they do. Which of the answers on the card I am showing you best describes why you answered as you did?

(1) That is what the project is worth to me
(2) I can't afford to pay a one time assessment
(3) People shouldn't have to pay for flood control
(4) The one time payment is unfair
(5) I object to the way the question is worded
(6) I don't think the project will affect flooding in this area.
(7) other _____(specify)
(8) no answer to Q19
(9) not applicable

Imagine, if you will, that the previous payment situation had never taken place. I will now present you with a different way of paying for the project.

Payment Method 2: Annual payment

21. Suppose that the cost of the project will be paid by property owners by a special assessment to be paid once a year for fifteen years after the project is built. You would be liable for the yearly assessment only if you maintain ownership of this property.

Here is a card with amounts of money on it. What is the most you would be willing to pay every year, for at most the next 15 years, to help pay for the flood control project? In your response feel free to choose any amount on the card or any number that lies between or is greater than the displayed numbers.

0	25	30	35	40	45
50	60	70	80	90	100
125	150	175	200	225	250
300	350	400	450	500	550

Bid 1 -- write the response here 0 - 550 -- if 0 go to 22. Q21a

If the amount you just told me was not enough to build the project and if the project was not constructed unless enough money was collected would you be willing to pay more?

( ) yes -- if yes, then go to Bid 2

( ) no

Bid 2 -- How much more of an annual payment would you be willing to make to help pay for the project? $_____. Q21b

(SUM BID1+BID2 _____) Is $_____ what you would be willing to pay for the project? Q21c

( ) yes

( ) no -- if no, go to Bid 3

Bid 3 -- Between $(response for bid 1) and $(bid 1 + bid 2) what is the most you would be willing to pay for the project in an annual assessment.

22. PROTEST 2: -- if willingness to pay = 0 Q22

We have found in studies of this type that people have a lot of reasons for answering as they do. Which of the answers on the card I am showing you best describes why you answered as you did?

(1) That is what the project is worth to me
(2) I can't afford to pay
(3) People shouldn't have to pay for flood control
(4) I object to the way the question is worded
(5) I don't think the project will affect flooding in this area.
(6) other_____(specify)
(8) no answer to Q21
(9) not applicable

The following background questions will enable our research staff to analyze the results of this survey.

23. Do you have any immediate plans to move from your current address? Q23

(1) Yes

(0) no -- if no, go to 25

24. What are your reasons for moving? Q24

(1) Flooding
(2) Job Change
(3) Moving to a larger house
(4) Other, specify_____
(9) not applicable

25. Please indicate what category represents your age? Q25

20-30	31-40	41-50	51-60	61-70	70+
1	2	3	4	5	6

26. Gender of respondent: Male (0) or Female (1) Q26

27. How many adult members are in your household? (1 - 5) Q27

28. How many children live in this household? (0 - 2) Q28

29. What is the highest level of education completed by yourself? Q29

											13	14	15	16	17	18	19	20	
1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	MA	JD	MD	PhD
Grade School								High School				College				Professional			

30. In what category would you say your household's income from all sources for 1986 falls? Q30

(1)	0	-	10,000
(2)	10,001-		20,000
(3)	20,001-		30,000
(4)	30,001-		40,000
(5)	40,001-		50,000
(6)	50,001-		60,000
(7)	60,001-		70,000
(8)	70,001-		and up

Do you have any questions?

Thank you for your help.

End time: Not Coded

APPENDIX A.3
SURVEY PARTICIPATION

Summary of Survey Participation

There were 141 residential parcels identified in the survey site. After obtaining the owner's names and addresses it was found that seven individuals owned two parcels in the survey site leaving a total of 134 landowners eligible to participate in the survey. Table A.3.1 provides a summary of total number of interviews scheduled and conducted and the number of landowners that did not participate in the survey. Table A.3.2 categorizes the reasons why landowner's did not participate and the number of individuals that fall into each category.

Table A.3.1: Summary of Interview Participation

Total number of landowner's	134
Total number of interviews scheduled	90
Total number of interviews conducted	86
Total number of nonparticipants*	48

*Includes landowner's who scheduled interviews but were not home at the appointed time.

Table A.3.2: Summary of Survey Nonparticipants

Number Not Contacted by Mail or Telephone	23
Number of undeliverable letters	6
Number of scheduled interviews not conducted	4
Number of refusals due to illness	5
Number of refusals due to sale of property	5
Number of refusals by mail; no reason given	5
Total Number of Nonparticipants	48

APPENDIX A.4
SUMMARY OF COMMENTS FROM INTERVIEWEES

Introduction

During the interview process the interviewees were free to express a variety of comments with regard to their views on flooding and flood control. This appendix is a compilation of the opinions and comments expressed by the survey participants. Note, however, that the comments listed in the appendix are not direct quotes. Additionally, a limited discussion of, and interpretation of these comments is included. The comments that are included below were recorded on the questionnaire for each interviewee. However, there were many instances in which comments were expressed that were not recorded because the flow of the interview would have been interrupted. Therefore, whenever appropriate, an asterisk (*) is used to indicate an opinion or attitude that was expressed with greater frequency than indicated by the written record for each interview. The appendix is organized into sections based on the specific question that was asked. In each section the comments that were prompted by each questions are listed and the frequency with which each comment was stated is indicated. Whenever relevant a brief discussion follows the comments.

Question 8: The Affect of the 1985 Flood on Neighborliness

When asked how the 1985 flood had affected the sense of community or neighborliness in their neighborhood, the respondents expressed the following concerns:

1. the neighborhood is deteriorating because our neighbors are leaving because of the flood (2)

2. the 1985 flood lowered property values and has made it impossible to sell my house *(15)

3. the 1985 flood forced people to clean-up and improve their homes (1)

4. the 1985 flood has caused people to sell their property and the buyers have rented the property resulting in a lowered sense of community *(2)

Questions 14 and 15: The Effect of the Project on Community and House

After being informed of the project's effect on the community of Roanoke and on the chance of flooding at the landowner's property the following comments were recorded:

1. What might happen if the project does not work? (6)

2. The project will be beneficial because Roanoke Memorial hospital will be protected. (11)

3. The project will be good as long as it is maintained. (1)

4. What will the project entail? *(10)

The questionnaire was not designed to provide a physical description of the Roanoke river flood control project. However, so many interviewees, far more than the 10 indicated above, requested a description of the project that a pair of figures depicting the project features in their neighborhood were prepared and shown to the respondent if a project description was requested.

Questions 16 & 18: Expectations for Property Value and Flood Insurance Premium Changes

After being informed of the project's effects on the community and the respondent's home the respondent was asked how he felt the project would affect property values and flood insurance premiums. In response to these questions the following comments were expressed:

1. The neighborhood is deteriorating so property values will go down regardless of the project. (3)

2. Property values are going up even without the project it is hard to say what affect the project will have. (1)

3. Property values may go up but people will wait and see if the project works before values will increase. (1)

4. Property values will go up because the city will increase the value of property. *(2)

5. Flood insurance premiums will go up--everything does. *(3)

The comment that property values will go up because the city will increase the value of the property stems from a confusion between real estate markets and the assessed value of property for tax purposes. The opinion that flood insurance premiums will go up is likely due to a lack of understanding of the way flood insurance premiums are determined. In fact, of the individuals that had purchased flood insurance, very few demonstrated an understanding of the relationship between premium changes and the likelihood of flooding.

Comments in Response to Anxiety Questions (Q9-Q12)

The anxiety portion of the questionnaire prompted a range of opinions and attitudes from carefree to tearful. In nearly every instance the respondent's prefaced their remarks by saying, "I don't worry about the river unless it rains a lot." The following additional comments were also recorded:

1. When a flood comes you just have to deal with it. (1)

2. I would be less anxious about the river if I were younger *(3)

3. People living on the flood plain are trapped because they cannot afford to sell their property or no one will buy it. *(1)

4. The trauma of the 1985 flood was worse than my property losses. (1)

5. If you live next to the river you have to expect something. (1)

Comments on the Project Description

During the course of the interviews several questions were asked with regard to the specific components of the Roanoke river flood control project. The following comments were made in response to that project description.

1. Over time the river has been flooding or nearly flooding with greater frequency and higher flood levels. (1)

2. The river is flooding because of upstream development. (1)

3. Unless the bridge near the water treatment plant is modified the project will not do any good. (1)

4. What will be done with the islands in the river? *(4)

5. The river should be dredged. (6)

6. Will the project take land from my property or anyone else's property? *(5)

The survey respondents were particularly concerned that the flood control project would require the condemnation of peoples' homes or would require them to give up a portion of their property. There fears were heightened because of recent publicity about a proposed recreational park called the Explorer project that would be built in their area. Some respondents told of being asked if they would be willing to sell their homes to provide the needed land for the Explorer project. An additional source of concern was voiced over what the Corps of Engineers planned to do with several large islands that had developed and were getting larger due to debris left from the 1985 flood.

Comments on the Payment Questions

When individuals were asked to pay for the flood control project the reactions ranged from compliance to outrage. The next section reports the comments that are related to protest bids. The comments below were recorded as responses to the method of paying for the project.

1. I'm willing to pay my fair share but only if everyone pays something.

2. The method of payment should be put to a vote. (1)

3. I don't want to commit to an annual payment because of my age. (3)

4. I don't want to commit to an annual payment because I plan to sell my property and don't want to pass on the cost to the future owner. (2)

5. The annual payment is nothing more than a tax. (1)

6. The annual payment is easier on the pocketbook. *(2)

7. Why is the annual payment required for 15 years? (3)

8. I don't have any basis for making a bid. (3)

9. The lump sum payment is unfair. *(2)

In addition to these comments it was observed that in at least five instances the lump sum bid was used as an anchoring point for the annual payment bid.

Comments Received as Protests to the Payment Questions

The following comments were recorded protest responses to the payment question.

1. I don't like the City of Roanoke because: *(9)

    a. the Southeast is treated like a bastard son.

    b. too much money has been misspent that should have been spent on flood control.

    c. the city failed to give promised cleanup assistance following the 1985 flood.

    d. the city planners are incompetent.

2. I already pay too many taxes and if the Federal government is involved it should pay for the project. *(9)

3. Too much money is being spent on the Explorer project instead of flood control. *(5)

4. Too much time and money has been spent on studies instead of action.

5. The river should be left in its natural state. (1)

6. People on the hill don't care about the people in the flood plain. *(1)

In addition to the comments reported above, four individuals reported that they had discussed the survey with their neighbor who had already been interviewed. It is likely that these discussions influenced the comments above and influenced the decision to protest having to pay for the project.

APPENDIX B

ROANOKE REFERENDUM TELEPHONE SURVEY FORM

1. Are you a registered voter whose permanent residence is located in the City of Roanoke? (NOT Roanoke County, Salem, or Vinton.)

   ____ YES (continue to Q. 2)
   ____ NO (record T-1 and Terminate)
   ____ REFUSED (record T-1 and Terminate)

2. On Tuesday, April 11, the voters of the City of Roanoke were asked to vote on a bond issue. If the bond issue passed, an increase in the city utility tax would be used to help pay for a flood control project along the Roanoke River within the city limits.

   Ask: Did you vote in the referendum on Tuesday, April 11, or not?

   (1) YES, VOTED (skip to Q. 4)
   (2) NO, DID NOT VOTE (Ask Q. 3)

3. Were you aware at the time that there was to be a referendum vote on Tuesday, April 11, or not?

   (1) YES, AWARE (skip to Q. 6)
   (2) NO, NOT AWARE (record T-3 and Terminate)
   (3) NOT SURE IF AWARE (record T-3 and Terminate)

VOTERS

4. At the time you voted, did you believe that your utility taxes would increase if the bond issue passed?

   (1) YES, BELIEVED UTILITY TAXES WOULD GO UP (ask Q. 5)
   (2) NO, DIDNT BELIEVE UTILITY TAXES WOULD GO UP(skip to Q.6)
   (3) WAS NOT SURE (skip to Q. 6)

5. How much MORE in dollars did you expect you would pay in utility taxes per month if the bond issue passed?

01 to 97	Actual dollar amount
98	$98 or more
99	Don't know

ATTITUDES TOWARD POSSIBLE FLOODING

6. Thinking about the overall issue of flooding in the Roanoke area..... Do you feel that the threat of flooding hurts the future development of the Roanoke community, or not?

   (1) YES
   (2) NO
   (3) NOT SURE

7. All things considered, do you feel that the proposed flood control project is the best approach to solving the flooding problem in Roanoke, or not?

   (1) YES
   (2) NO
   (3) NO SURE

8. On balance, how do you feel the flood control project will affect the environment along the Roanoke River? Will the flood control project (READ):

   (1) HARM THE ENVIRONMENT ALONG THE RIVER
   (2) IMPROVE THE ENVIRONMENT ALONG THE RIVER
   (3) WILL IT NOT AFFECT THE ENVIRONMENT ALONG THE RIVER
   (4) DON'T KNOW

9. On balance, how do you feel the flood control project will affect the recreational opportunities along the river? Will the flood control project (READ):

   (1) HARM THE RECREATIONAL OPPORTUNITIES ALONG THE RIVER
   (2) IMPROVE THE RECREATIONAL OPPORTUNITIES ALONG THE RIVER
   (3) IT WILL NOT AFFECT THE RECREATIONAL OPPORTUNITIES ALONG THE RIVER
   (4) DON'T KNOW

BEFORE ASKING Q. 10, REFER TO Q. 2:
* IF "VOTED": ASK Q.10
* IF "DID NOT VOTE," SKIP TO Q.13.

HOW VOTED

10. Earlier you said you voted in the Tuesday, April 11 referendum.... Did you vote FOR or AGAINST the bond issue?

(1) FOR (ask Q. 11)
(2) AGAINST (skip to Q. 12)
(3) REFUSED TO ANSWER (skip to Q. 19)

VOTED "FOR"

11. In your own words, what would you say was your single most important reason for voting FOR the bond issue?
(ONE ANSWER -- DO NOT READ)

(1) PROJECT WOULD IMPROVE THE ENVIRONMENT
(2) PROJECT WOULD PROTECT MY HOME OR PLACE OF WORK FROM FLOODING
(3) PROJECT WOULD PROVIDE A BOOST TO THE ROANOKE ECONOMY
(4) PROJECT WOULD HELP PEOPLE IN THE CITY WHO SUFFER FROM FLOODING
(5) PROJECT WOULD INCREASE RECREATIONAL OPPORTUNITIES ON THE ROANOKE RIVER
(6) WE NEED PROTECTIVE MEASURES/DO NOT HAVE CURRENT FLOOD CONTROL PLAN
(7) OTHER RESPONSES
(8) DON'T KNOW
ALL SKIP TO Q.19

VOTED "AGAINST"

12. In your own words, what would you say was your single most important reason for voting AGAINST the bond issue?
(ONE ANSWER -- DO NOT READ)

(1) PROJECT WOULD HARM THE ENVIRONMENT
(2) PROJECT WOULD NOT BE EFFECTIVE IN PROTECTING MY HOME OR PLACE OF WORK FROM FLOODING
(3) PROJECT IS NOT IMPORTANT TO THE ROANOKE ECONOMY
(4) PEOPLE AND BUSINESSES LOCATED ALONG THE RIVER SHOULD PAY FOR THE PROJECT
(5) I OPPOSE HIGHER UTILITY TAXES
(6) PROJECT IS NOT THE BEST APPROACH/SOLUTION TO SOLVING FLOODING
(7) PROJECT WOULD HARM RECREATIONAL OPPORTUNITIES ALONG RIVER
(8) PROJECT WILL COST MORE THAN THE CITY SAYS IT WILL COST
(9) UNNECESSARY EXPENSE
(10) DO NOT BELIEVE FLOODING WILL OCCUR
(24) OTHER
(25) REFUSE
ALL SKIP TO Q. 19

NON-VOTERS

13. Earlier, you said you were aware of the Tuesday, April 11 referendum but did not actually vote in the referendum... What would you say was your single most important reason for not voting in the Tuesday, April 11 referendum?
ONE ANSWER -- DO NOT READ

(1) DID NOT HAVE ENOUGH INFORMATION ABOUT THE ISSUE
(2) DID NOT CARE ABOUT THE FLOOD CONTROL PROJECT
(3) IT WAS INCONVENIENT TO VOTE APRIL 11 (COULDN'T TAKE TIME OFF WORK, OUT OF TIME, ETC.)
(4) I WAS SURE THE BOND ISSUE WOULD PASS
(5) I WAS SURE THE BOND ISSUE WOULD FAIL
(6) FORGOT/DIDN'T KNOW DATA
(7) I WAS UNDECIDED ON THE ISSUE
(8) I AM OPPOSED TO THE BOND ISSUE
(9) DON'T SEE HOW IT WILL HELP/NOT THE RIGHT SOLUTION
(24) OTHER
(25) REFUSED

14. Before the referendum, did you believe that you would have to pay higher utility taxes if the bond issue passed?

(1) YES (ask Q. 15)
(2) NO (skip to Q. 16)
(3) NOT SURE (skip to Q. 16)

15. How much MORE in dollars did you expect you would pay in utility taxes per month if the bond issue passed?

01 to 97	Actual dollar amount
98	$98 or more
99	Don't know

HOW VOTED

16. If you had voted in the referendum on the Tuesday, April 11 how would you have voted -- would you have voted FOR or AGAINST the bond issue?

(1) FOR (ask Q. 17)
(2) AGAINST (skip to Q. 18)
(3) REFUSED TO ANSWER (skip to Q. 19)

IF HAD VOTED "FOR"

17. In your own words, what would have been the single most important reason why you would have voted FOR the bond issue?
(ONE ANSWER -- DO NOT READ)

(1) PROJECT WOULD IMPROVE THE ENVIRONMENT
(2) PROJECT WOULD PROTECT MY HOME OR PLACE OF WORK FROM FLOODING
(3) PROJECT WOULD PROVIDE A BOOST TO THE ROANOKE ECONOMY
(4) PROJECT WOULD HELP PEOPLE IN THE CITY WHO SUFFER FROM FLOODING
(5) PROJECT WOULD INCREASE RECREATIONAL OPPORTUNITIES ON THE ROANOKE RIVER
(6) WE NEED PROTECTIVE MEASURES/DO NOT HAVE CURRENT FLOOD CONTROL PLAN
(24) OTHER RESPONSES
(25) DON'T KNOW
ALL SKIP TO Q.19

IF HAD VOTED "AGAINST"

18. In your own words, what would have been the single most important reason why you would have voted AGAINST the bond issue?
(ONE ANSWER -- DO NOT READ)

(1) PROJECT WOULD HARM THE ENVIRONMENT
(2) PROJECT WOULD NOT BE EFFECTIVE IN PROTECTING MY HOME OR PLACE OF WORK FROM FLOODING
(3) PROJECT IS NOT IMPORTANT TO THE ROANOKE ECONOMY
(4) PEOPLE AND BUSINESSES LOCATED ALONG THE RIVER SHOULD PAY FOR THE PROJECT
(5) I OPPOSE HIGHER UTILITY TAXES
(6) PROJECT IS NOT THE BEST APPROACH/SOLUTION TO SOLVING FLOODING
(7) PROJECT WOULD HARM RECREATIONAL OPPORTUNITIES ALONG RIVER
(8) PROJECT WILL COST MORE THAN THE CITY SAYS IT WILL COST
(9) UNNECESSARY EXPENSE
(10) DO NOT BELIEVE FLOODING WILL OCCUR
(24) OTHER
(25) REFUSE
ALL SKIP TO Q. 19

PAYMENT FOR PROJECT

19. There are several alternative ways the flood control project could be paid for.

In your opinion, which of the following ways should the city use to pay for the flood control project? Should it be (READ):

(1) OUT OF CURRENT TAXES
(2) WITH A TAX INCREASE FOR EVERYONE IN THE CITY
(3) WITH A TAX INCREASE ONLY FOR PEOPLE WITH HOMES AND BUSINESSES ALONG THE RIVER
(4) DO YOU FEEL THE CITY SHOULDN'T HAVE TO PAY
(5) NOT SURE

SOURCES OF INFORMATION

20. Now I would like to ask you about how you learned about the project and the bond issue referendum.

Did you get information about the project and bond issue from: (READ LIST - CHECK ALL THAT APPLY)

	YES	NO
NEWSPAPERS	____	____
TELEVISION AND RADIO	____	____
FRIENDS AND NEIGHBORS	____	____
INFORMATION RECEIVED IN THE MAIL	____	____
INFORMATION PROVIDED AT WORK	____	____

- If more than one "Yes" in Q. 20, ask Q. 21.

21. Which one of these information sources was the single most important to you in determining your view about the bond issue?

(1) NEWSPAPERS
(2) TELEVISION AND RADIO
(3) FRIENDS AND NEIGHBORS
(4) INFORMATION RECEIVED IN THE MAIL
(5) INFORMATION PROVIDED AT WORK
(6) ALL EQUAL
(7) NOT SURE

NEXT I WOULD LIKE TO ASK ABOUT YOUR EXPERIENCE WITH FLOODING..

22. During the flood in Roanoke in 1985, did flood water enter the home or basement where you lived in 1985?

(1) YES
(2) NO (skip to Q. 24)

23. Do you still live in the home today that was flooded in 1985?

(1) YES (skip to Q. 25)
(2) NO

24. Do you now own or rent property that was flooded during the flood in Roanoke in 1985?

(1) YES
(2) NO
(3) NOT SURE
(NOTE: if "yes" in Q. 23, circle YES in Q. 24)

25. Based on what you've heard or read, do you feel the proposed flood control project would effectively protect your present home from flooding, or not?

(1) YES
(2) NO
(3) NOT SURE

26. During the flood in Roanoke in 1985, did flood water enter the home or basement of a close friend or relative?

(1) YES
(2) NO

27. Are you now employed by a business which was forced to temporarily close down during the flood in Roanoke in 1985?

(1) YES
(2) NO
(3) NOT SURE
(4) RETIRED

28. Based on what you've heard or read, do you feel the proposed flood control project would effectively protect your current place of work from flooding, or not?

(1) YES
(2) NO
(3) NOT SURE
(4) RETIRED

IMPACT OF UTILITY BILLS

29. The bond issue proposed that utility taxes be increased to finance bonds to pay for the flood control project. In order to estimate the effect of the increase on citizens of the city we need to know the AVERAGE AMOUNT you now pay for the following utilities each month.

First, do you pay your (insert bill) directly, or is it paid some other way, such as through your rent?

	Respondent Pays	Landlord Pays
MONTHLY ELECTRIC BILL	1	2
MONTHLY NATURAL GAS BILL	1	2
MONTHLY TELEPHONE BILL	1	2
WATER AND SEWER BILL	1	2

For all circled ask Q. 30

30. (For all paid by respondent ask:) How much is your average bill per month?

MONTHLY ELECTRIC BILL
- 01-997 actual dollar amount
- 998 don't know refused
- 999 landlord pays

MONTHLY NATURAL GAS BILL
- 01-997 actual dollar amount
- 998 don't know refused
- 999 landlord pays

MONTHLY TELEPHONE BILL
- 01-997 actual dollar amount
- 998 don't know refused
- 999 landlord pays

WATER AND SEWER BILL
- 01-997 actual dollar amount
- 998 don't know refused
- 999 landlord pays

RESIDENT CHARACTERISTICS

31. Do you now own, rent, or lease property of any type located in the flood plain area near the Roanoke River, or not?

(1) YES
(2) NO
(3) REFUSED

32. Thinking just about your current place of residence, do you own or do you rent your current place of residence?

(1) YES
(2) NO
(3) REFUSED

33. Do you currently live in the same place of residence you lived in (insert year), or not?

	1985	1987
YES	1	1
NO	2	2
REFUSED	3	3

34. To help us interpret the results of our study, could you please give me the current street address and the zip code for your place or residence?

STREET ADDRESS: _____
ZIP CODE: _____

35. Finally, in which of the following categories was your approximate total annual household INCOME for 1988? Was it:

(1) Less than $10,000
(2) $10,000 - $19,999
(3) $20,000 - $29,999
(4) $30,000 - $39,999
(5) $40,000 - $49,999
(6) $50,000 - $59,999
(7) $60,000 or more
(8) REFUSED

36. Gender

(1) MALE
(2) FEMALE

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Leonard Shabman, Kurt Stephenson, Eric Thunberg, and Brian Dietz with Paul Driscoll and Kevin O'Grady

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USACE, Water Resources Support Center
Institute for Water Resources
Casey Building, 7701 Telegraph Road
Alexandria, VA 22315-3868

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13. ABSTRACT (Maximum 200 words)

This report is a product of the U.S. Army Corps of Engineers' Risk Analysis for Water Resources Investments Research Program. The purpose of this research was to evaluate the differences and potential strengths and weaknesses of different methods for evaluating consumers' willingness to pay for a public good, i.e., a flood hazard reduction project. Three methods are compared and contrasted both collectively and against the theory of revealed consumer preference. These methods are the Property Damages Avoided (PDA) approach, Hedonic Price Method (Land Price Analysis), and the Contingent Value Method (CVM).

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hedonic price, contingent value, willingness to pay, flood risk, flood hazard reduction benefits, revealed consumer preference.

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